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Convolvulus carrii, a new species

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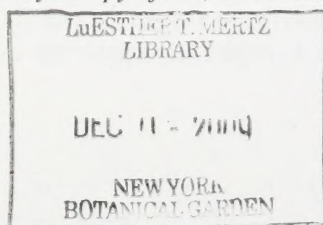
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**JUNIPERUS RECURVA VAR. UNCINATA, THE HOOKED
BRANCHLET JUNIPER, A NEW VARIETY FROM NEPAL**

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ABSTRACT

Routine field work in Nepal led to the discovery of a new variety of *J. recurva* (*J. recurva* var. *uncinata* R. P. Adams), the hooked branchlet juniper, a shrub with short leaves and hooked or recurved branchlet tips, growing at 3900 m. Analyses of sequence data from nrDNA and cpDNA (petN-psbM) of *Juniperus indica*, *J. i. var. caespitosa*, *J. i. var. rushforthiana*, *J. recurva* and *J. squamata* confirmed the distinct nature of the new variety. Analyses of leaf terpenoids from the parents, and several intermediates between *J. recurva* and *J. r. var. uncinata* support hybridization. *Phytologia* 91(3): 361-382 (December, 2009).

KEY WORDS: *Juniperus indica*, *J. i. var. caespitosa*, *J. i. var. rushforthiana*, *J. recurva*, *J. recurva* var. *uncinata* R. P. Adams, **var. nov.**, *J. squamata*, SNPs, nrDNA (ITS), petN, psbM, sequences, terpenoids, taxonomy, hybridization.

The junipers of the central Himalayans consist of *J. communis* L. var. *saxatilis* Pall., *J. indica* Bertol. var. *caespitosa* Farjon, *J. i. var.*

indica Bertol., *J. i.* var. *rushforthiana* R. P. Adams, *J. recurva* Buch.-Ham. ex D. Don, and *J. squamata* Buch.-Ham. ex D. Don (Adams, 2008). While collecting specimens of *J. recurva* in Nepal, we discovered a shrub that differs from typical *J. recurva* in having branchlet tips that are hook-shaped, having shorter leaves, and branching near the base. In addition, several plants were found that appear to be intermediate between typical *J. recurva* and the newly discovered 'hooked-tip' plants.

The purpose of this paper is to report on analyses of *J. recurva*, the newly discovered hooked-tipped shrubs and compare these with closely related species (*Juniperus indica*, *J. i.* var. *caespitosa*, *J. i.* var. *rushforthiana*, *J. squamata*) using nrDNA (ITS) and cp petN-psbM SNPs. In addition, the volatile leaf terpenoids from the *J. recurva* plants and putative hybrids were analyzed.

MATERIALS AND METHODS

Specimens (GenBank nrDNA, petN-psbM) used in this study: *J. indica* var. *indica*, Adams 8775-8777, (GQ118641, GQ118648), L. Singh, Dumpa, Jomson, 2900 m, Nepal; *J. indica* var. *caespitosa*, Adams 7625-7627 (GQ118642, GQ118649), R. Chaudhary, between Kyangjin Gompa and Langtang Glacier, 4000 m, Nepal; *J. indica* var. *rushforthiana*, Adams 8140, 8141, (GQ118643, GQ118650), K. Rushforth, Soe Tajitang, 3000 m and Lingshi, 3480 m, Bhutan, *J. recurva* var. *recurva*, Adams 7210, 7211, 7215, 7217-7219 (GQ118644, GQ118651), between Sing Gompa and Cholan Pati lodge, 3360-3570 m, Nepal; *J. recurva* var. *uncinata*, Adams 7212-7214 (GQ118645, GQ118652) Lauri Binayak, 3900 m, Nepal, *J. squamata* var. *squamata*, Adams 6796, (GQ118646, GQ118653) Xian Botanical Garden, China, 7012, Kunming Botanical Garden, China, *J. squamata* f. *wilsonii*, Adams 5521 (GQ118647, GQ118654), Arnold Arboretum, acc.1010-64A. Voucher specimens are deposited at BAYLU.

One gram (fresh weight) of the foliage was placed in 20 g of activated silica gel and transported to the lab, thence stored at -20° C until the DNA was extracted. DNA was extracted from juniper leaves by use of a Qiagen mini-plant kit as per manufacturer's instructions.

Amplification and sequencing

ITS (nrDNA) and petN-psbM amplifications were performed in 30 µl reactions using 6 ng of genomic DNA, 1.5 units Epi-Centre Fail-Safe Taq polymerase, 15 µl 2x buffer E or K (final concentration: 50 mM KCl, 50 mM Tris-HCl (pH 8.3), 200 µM each dNTP, plus Epi-Centre proprietary enhancers with 1.5 - 3.5 mM MgCl₂ according to the buffer used) and 1.8 µM each primer.

Gene	Primers	2x buffer	annealing	program	size bp
nrDNA	ITSA-42F/ ITSB+57R	K	50°C	(94-50x30)	1106-141
petN	petN5F/psbM111R	E	50°C	(94-50x30)	741-825

Primers (5'-3'):

ITS: ITSA = GGA AGG AGA AGT CGT AAC AAG G;

ITSB = CTT TTC CTC CGC TTA TTG ATA TG.

ITSA and ITSB primers from Blattner (1999).

additional ITS primers (based on *Juniperus* sequences):

ITSA-42F = GAT TGA ATG ATC CGG TGA AGT

ITSB+57R = ATT TTC ATG CTG GGC TCT

petN - psbM:

petN5F = AAC GAA GCG AAA ATC AAT CA

psbM111R = AAA GAG AGG GAT TCG TAT GGA

petN and psbM primers were based on conserved sequences from *Juniperus* species.

The following PCR conditions were used: MJ Research Programmable Thermal Cycler, 30 cycles, 94°C (1 min.), 50°C (2 min.), 72°C (2 min.), with a final step of 72°C (5 min.). The PCR reaction was subjected to purification by agarose gel electrophoresis (1.5% agarose, 70 v, 55 min.). In each case, the single band was excised and purified using a Qiagen QIAquick gel extraction kit. The gel purified DNA band with the appropriate primer was sent to McLab Inc. for sequencing. Sequences for both strands were edited and a consensus sequence was produced using Chromas, version 2.31 (Technelysium Pty Ltd.). Alignments were made using MAFFT (<http://align.bmr.kyushu-u.ac.jp/mafft/>), manually corrected, and re-analyzed using NJ with 1000 bootstrap replications (<http://align.bmr.kyushu-u.ac.jp/mafft/>).

Isolation and analysis of Oils - see Adams et al. (2009). *Data Analysis* - Terpenoids (as per cent total oil) were coded and compared among the taxa by the Gower metric (Gower, 1971). Principal coordinate analysis was performed by factoring the associational matrix using the formulation of Gower (1966) and Veldman (1967).

RESULTS AND DISCUSSION

The hooked branchlet junipers were found at 3900 m on a south facing slope at timberline at Lauri Binayak (Fig. 1). A large population of *J. recurva* grew just west of Sing Gompa (Fig. 1) and other individual *J. recurva* plants were found between Sing Gompa and Cholan Pati lodge (Fig. 1). Plants morphologically intermediate between *J. recurva* and the hooked branchlets junipers were found around Cholan Pati between 3400 and 3600 m (Fig. 1). The small elevation change between Sing Gompa (3400 m) and Lauri Binayak (3800 m) appears sufficient to cause habitat differences that support typical *J. recurva* and the hooked-tip juniper, as well as intermediate habitats around Cholan Pati.

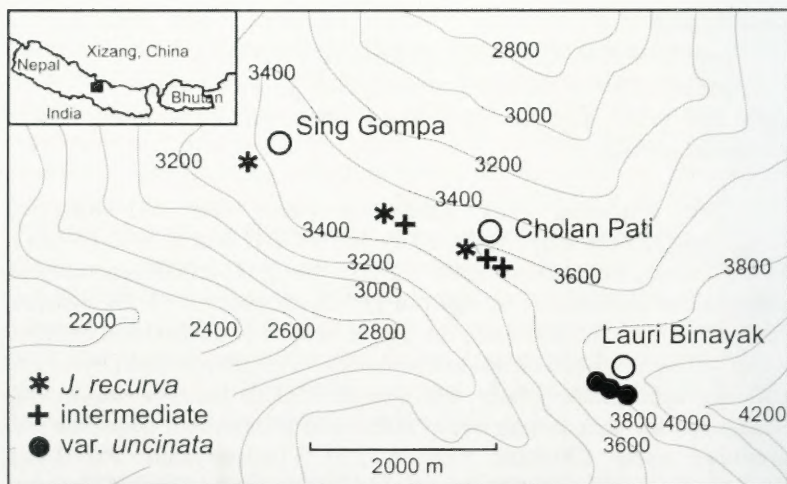


Figure 1. Site map of juniper collections between Sing Gompa and Lauri Binayak, Nepal.

The hooked branchlet junipers near Lauri Binayak are recognized as a new variety of *J. recurva*:

Juniperus recurva* var. *uncinata R. P. Adams, **var. nov.** TYPE: Nepal, 100 m s of Lauri Binayak, N 28 05.537', E 85 22.879', 3900 m, on south facing slope, 0.5 m x 0.5 m shrub, 1 Nov 1993, *Adams 7212* (HOLOTYPE: BAYLU, TOPOTYPES: *Adams 7213, 7214, BAYLU*), Fig. 2).

Junipero recurvae similis sed differt habitu fruticoso, apicibus ramulorum unciniformibus vel recurvatis, et foliis brevibus (20–28 mm).

Similar to *Juniperus recurva*, but differing in that the branchlet tips are hooked or recurved, the leaves are short (20 - 28 mm) and it grows as a shrub.

The terminal branchlet tips of var. *uncinata* are striking as they form a hook at their tips (Fig. 2), in contrast to var. *recurva* that has lax tips that are not hooked (Fig. 3). The leaves of *uncinata* are 20 - 28 mm long, compared to 35-50 mm in var. *recurva* (Figs. 2, 3). In addition, var. *uncinata* is multi-stemmed at the base whereas var. *recurva* has a strong central axis, even when appearing as a shrub.

It appears that the two varieties hybridize in the area around Cholan Pati. A putative hybrid (*Adams 7211*) is shown in Fig. 4. Note that the hooked branchlets are like those of var. *uncinata*, but the longer leaves are like var. *recurva*; this plant was a shrub, branched at the base, 1 m wide x 1 m tall. Due to the cutting of limbs for use as incense, many of the trees in this area appear as shrub-like.

In addition to hybrids, individuals were found that appear to be back-crossed, or of a F₂ generation. *Adams 7210* is from a shrub, 4 m wide x 0.7 m tall, with very small leaves, but the branchlet tips are scarcely hooked (Fig. 5), suggesting the presence of some genes from *J. recurva* var. *recurva* in an otherwise typical *J. r.* var. *uncinata* individual.



Fig. 2. *Juniperus recurva* var. *uncinata*, Holotype, Adams 7212.



Fig. 3. *Juniperus recurva* var. *recurva*. Adams 7219.



Fig. 4. Putative hybrid between *Juniperus recurva* var. *recurva* and *J. r.* var. *uncinata*, Adams 7211.



Fig. 5. Putative backcross of *J. recurva* var. *recurva* to *J. r.* var. *uncinata*, Adams 7210.

To gather additional information on the relationships within the *J. recurva* complex and other related taxa, the nrDNA (ITS region) was sequenced. This resulted in 1106 to 1141 bp of sequence data, with 19 mutational events that included 5 indels. A 29 bp deletion was found in all samples of *J. recurva* vars. *recurva* and *uncinata*. A 4 bp deletion was found in all var. *uncinata* and *J. squamata* samples. Eight of the mutational events were single occurrences and not deemed of taxonomic interest. This resulted in 11 events (simply noted as SNPs for discussion) that were used for analysis. An associational matrix was constructed using these 11 SNPs; the resulting minimum spanning network is shown in figure 6 (left). No variation was found among *J. recurva* var. *recurva* and only one SNP was found in *J. r.* var. *uncinata*

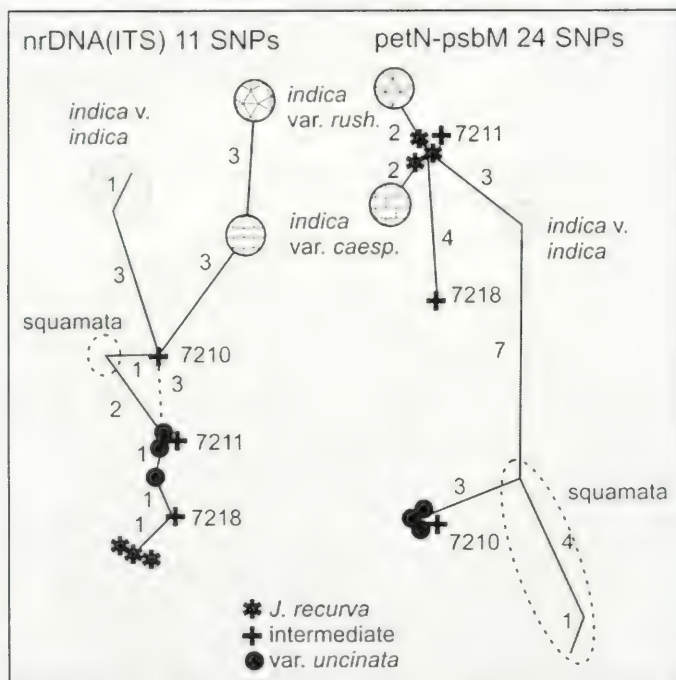


Figure 6. Left: Minimum spanning network based on 11 nrDNA SNPs. Right: Minimum spanning network based on 24 petN-psbM SNPs. The numbers next to the links are the number of SNPs. Dashed line (7210-7211) is the second nearest link.

(Fig. 6, left). No variation was found among the three *J. squamata* samples. However, the three varieties of *J. indica* showed considerable differences.

Sequencing the cp petN-spacer-psbM region resulted in 741-825 bp with 35 mutational events that included 9 indels. Five of the indels and 6 of the nucleotide mutations were single occurrence events (autapomorphies) and eliminated, leaving 24 informative mutational events that were utilized (herein called SNPs). An associational matrix was constructed using these 24 SNPs, and the resulting minimum spanning network is shown in figure 6 (right). Interestingly, again, no variation was found within *J. recurva* var. *uncinata* or among *J. r.* var. *recurva* (Fig. 6, right). However, the three *J. squamata* samples showed considerable variation. The three varieties of *J. indica*, as before, showed considerable differences, with *J. recurva* var. *recurva* being placed in the midst of the three *J. indica* varieties (Fig. 6, right).

The intermediate plants (7210, 7211, 7218) are plotted differently in each data set. Plant 7210 has 3 nrDNA mutations that separate it from all *J. recurva* plants (Fig. 6, left), but its cp petN-psbM sequences are identical to *J. recurva* var. *uncinata* (Fig. 6, right) suggesting that the male (pollen and cp transmitting) parent was *J. r.* var. *uncinata*. Plant 7211 is identical in its nrDNA to two of the *J. recurva* var. *uncinata* plants (Fig. 6, left), whereas, its cp petN-psbM sequence is identical to *J. recurva* var. *recurva* plants (Fig. 6, right), suggesting that the male parent was *J. r.* var. *recurva*. If this is correct, then gene flow seems to be bi-directional. Plant 7218 is intermediate in its nrDNA between *J. r.* var. *recurva* and var. *uncinata* (Fig. 6, left) and has 4 SNPs separating it from *J. r.* var. *recurva* (Fig. 6, right).

A minimum spanning network based on combining the 11 nrDNA and 24 petN-psbM SNPs shows that *J. recurva* var. *recurva* is well separated from *J. r.* var. *uncinata* (Fig. 7). The varieties of *J. indica* are nearly equidistant. The accessions of *J. squamata* show considerable differences.

The intermediate individuals largely follow the cp petN-psbM differences in that each are associated with either *J. r.* var. *recurva* (7211, 7218) or *J. r.* var. *uncinata* (7210) (Fig. 7). Although *J. r.* var.

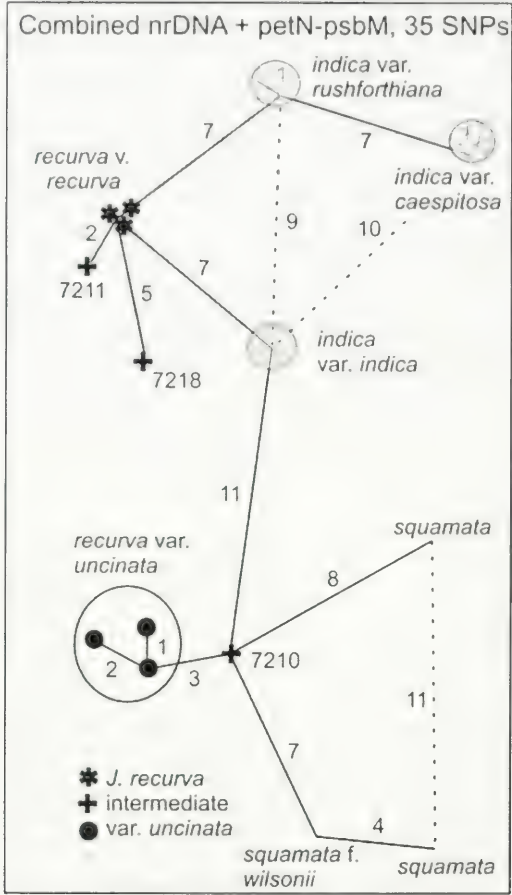


Figure 7. Minimum spanning network based on 11 nrDNA and 24 cp petN-psbM SNPs. The dotted lines show the 2nd nearest link. Numbers next to the links are the number of SNP differences.

uncinata appears to be as distinct from *J. r.* var. *recurva* as other species. However, due to the likely hybridization and intergradation, it seems unwise to recognize it at the specific level at this time.

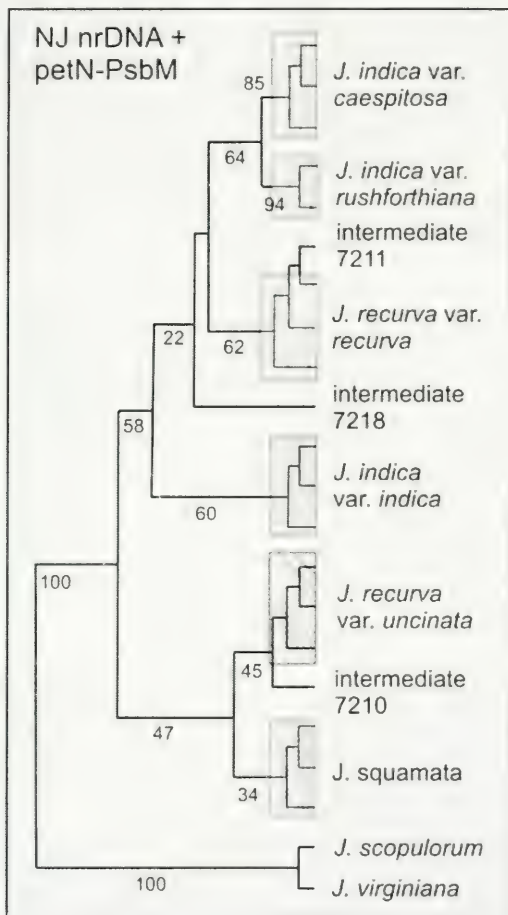


Figure 8. NJ tree based on nrDNA and cp petN-psbM sequences. The numbers on the branches are bootstrap probabilities (1000 reps.).

Another method to examine the sequence differences is by adding an outgroup (*J. scopulorum*, *J. virginiana*) to the data set and computing a NJ tree. Figure 8 shows a NJ tree based on combined nrDNA and petN-psbM sequences. Notice, although the species group

into clades, these clades are generally not well supported. The intermediate plants grouped with *J. r.* var. *recurva* (7211) or *J. r.* var. *uncinata* (7210), reflecting the male chloroplast donor. Intermediate plant 7218 is not closely associated with any clade.

There is weak support for *J. recurva* var. *uncinata* and *J. squamata* as a clade (Fig. 8, 47). Examination of the leaves of the taxa concerned, show (Fig. 9) that the leaves of *J. recurva* var. *uncinata* are very similar to those of *J. recurva* var. *recurva* and not like those of *J. squamata*. In addition, the gene-flow between var. *recurva* and var. *uncinata* suggest a very close relationship. It is also noteworthy that the leaves of *J. indica* and its varieties are scale-like and differ from the decurrent leaves of *J. recurva* var. *recurva* (Fig. 9) such that the placement of var. *recurva* within the *J. indica* clade is inconsistent with leaf morphology. Perhaps there are ancestral gene-patterns of *J. indica* that are still expressed in *J. recurva* var. *recurva* for the two gene regions sequenced.

Incomplete lineage sorting and gene coalescence

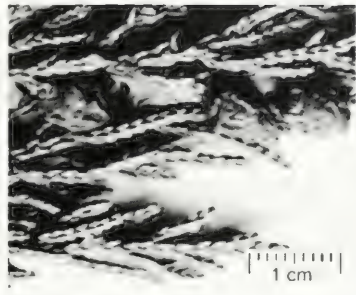
Degnan and Rosenberg (2009) define incomplete lineage sorting as "the failure of two or more lineages in a population to coalesce, leading to the possibility that at least one of the lineages first coalesces with a lineage from a less closely related population." Syring et al. (2007, Table 6) suggest that the number of years for monophyly to be more likely than paraphyly in *Pinus* may be from 1.7 to 24 Myr and it may take from 5.4 to 76 Myr for a species to attain a complete genome-wide coalescence. The oldest known fossil of *Juniperus* is from Europe (dated at 35 m yr bp, Kvacek, 2002). The Himalayas began to form with the collision of the Indian and Eurasian plates about 40-50 m yr bp (USGS, 2009). It may be that *J. indica* and *J. recurva* have had insufficient evolutionary time to fully complete lineage sorting (at least for the two gene regions sequenced in this study).

Leaf terpenoids and analysis of hybridization

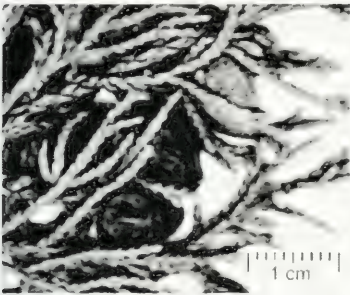
A more detailed examination of *J. r.* var. *recurva*, *J. r.* var. *uncinata* and putative hybrids was undertaken by examining the volatile leaf terpenoids. Table 1 shows the compositions of the oils of *J. recurva* from the study area (Fig. 1). The oils of var. *recurva* are high in α -pinene, sabinene, δ -3-carene, limonene, β -phellandrene and elemol



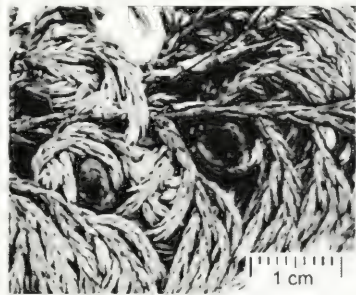
J. indica var. *indica*



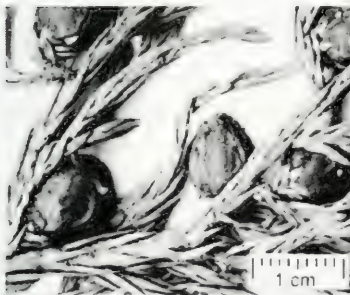
J. indica var. *caespitosa*



J. indica var. *rushforthiana*



J. recurva var. *uncinata*



J. recurva var. *recurva*



J. squamata var. *squamata*

Figure 9. Leaves and female cones of taxa in this study.

with moderate amounts of myrcene, terpinolene, terpinen-4-ol, pregeijerene B, γ -cudesmol and abietadiene (Table 1).

The leaf oils of var. *uncinata* are very high in δ -3-carene (27.0 - 37.0%) and high in terpinolene, trans-muurolo-4(14),5-diene, cubebol, δ -cadinene, with moderate amounts of α -pinene, sabinene, limonene, β -phellandrene, cis-muurolo-3,5-diene, and trans-cadina-1(6),4-diene (Table 1). Several compounds were present in var. *recurva*, but absent in var. *uncinata*: α -thujene, cis-sabinene hydrate, trans-sabinene hydrate, hexenyl isovalerate, linalyl acetate, germacrene B, humulene epoxide II, and γ -eudesmol. Two compounds were found in all var. *uncinata* oils but were absent in var. *recurva* oils: cis-limonene oxide and β -oplophenone (Table 1).

The intermediate plants (7210, 7211, 7218) often had intermediate values in their composition. Note α -thujene, α -pinene, δ -3-carene, terpinen-4-ol, cis-muurolo-3,5-diene, trans-cadina-1(6),4-diene, trans-muurolo-4(14),5-diene, δ -cadinene, elemol, γ -eudesmol, and abietadiene (Table 1). Two of the compounds exhibited a 'gigantism' in being markedly higher concentration in some of the intermediate plants: myrcene and β -phellandrene (Table 1).

Thirty eight of the terpenoids that were larger than trace amounts, and displayed fidelity within the taxa (boldface in Table 1), were used to compute an association matrix. Factoring the matrix resulted in two eigenroots that were larger than the average diagonal value, and likely biologically significant.

The first three eigenroots (47.3, 16.0, 10.3 % of the variance) were used to plot the individuals (Fig. 10). *Juniperus recurva* var. *recurva* individuals formed a looser cluster than those of var. *uncinata*. Two of the intermediate plants (7211, 7218) form the classical U triangle between parents and hybrids, exactly the ordination position that is expected for hybrids (see Adams, 1982, for a detailed examination of multivariate analysis of both synthetic and putative hybrids). The third intermediate plant (7210) is much closer to *J. r.* var. *uncinata* and behaves as a back-cross or F₂ generation plant in this ordination (Adams, 1982). It is interesting to note that none of the analyses of sequence data had the sensitivity to detect these hybrids, and/or back-crossed, individuals.

Pleines, Jakob and Blattner (2008) state "As tree-based methods are mostly insufficient to depict relationships within species, network approaches are better suitable to infer gene or locus genealogies. Problematic for phylogeographic studies are alleles shared among multiple species, which could result from either hybridization of incomplete lineage sorting." The results from the present study show that analysis of hybridization and introgression using multivariate statistical methods of quantitative data is more informative than the tree-based method utilized.

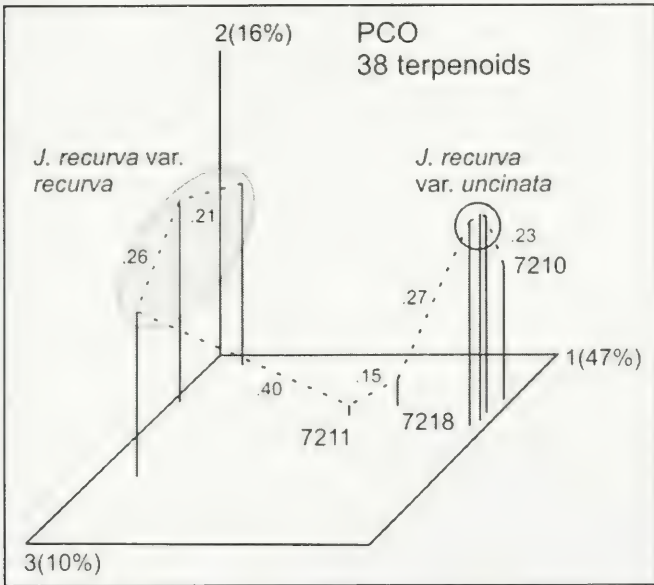


Figure 10. PCO of *J. recurva* individuals based on 38 terpenoids. The dashed line is the minimum spanning network and the values next to the links are the distance values between OTUs.

In summary, the recognition of the new variety, *J. recurva* var. *uncinata*, is supported by morphology, terpenoids and DNA sequence data. Additional research is needed to clarify the variation found in *J. squamata*.

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Table 1. Comparison of volatile leaf oils of *J. recurva* var. *recurva*, *J. r.* var. *uncinata* and intermediates.

Al	Compound	var. <i>recurva</i>			intermediate plants				var. <i>uncinata</i>			
		7219	7217	7215	7211	7218	7210	7212	7213	7214		
921	tricyclene	t	t	-	-	t	0.1	0.1	0.1	0.1		
924	α -thujene	0.2	0.6	0.4	0.2	0.3	t	-	-	-		
932	α -pinene	7.0	4.1	7.2	4.2	4.7	5.2	2.8	3.3	7.9		
945	α -fenchene	1.2	1.2	0.4	0.4	0.8	1.2	1.8	2.3	1.9		
961	verbenene	-	-	-	-	-	0.1	-	0.1	-		
969	sabinene	5.6	13.1	13.4	0.9	2.2	0.6	0.4	0.4	0.3		
974	β -pinene	0.3	0.2	t	0.1	t	0.3	0.2	0.3	0.3		
988	myrcene	3.7	2.0	1.7	8.7	14.2	2.2	1.2	1.4	1.1		
1008	δ -3-carene	18.1	16.4	8.4	6.8	10.8	21.1	32.1	37.0	27.0		
1014	α -terpinene	0.3	0.7	0.6	0.1	0.1	0.1	0.1	t	t		
1020	p-cymene	t	0.3	0.1	t	t	0.1	0.5	0.6	0.4		
1024	limonene	7.2	6.2	12.0	7.0	6.0	6.0	3.0	3.6	0.3		
1025	β -phellandrene	10.3	6.2	8.7	14.2	11.9	6.1	3.1	3.6	0.6		
1054	γ -terpinene	0.4	1.1	1.0	0.2	0.2	0.2	t	t	t		
1065	cis-sabinene hydrate	0.2	0.5	0.3	0.1	t	t	-	-	-		
1067	cis-linalool oxide(furanoid)	-	-	-	0.1	-	t	-	-	-		
1086	terpinolene	2.6	2.6	1.2	1.7	2.3	3.7	4.8	5.3	4.6		
1090	6,7-epoxy myrcene	t	-	-	t	-	-	-	-	-		
1096	trans-sabinene hydrate	0.1	0.2	t	t	t	-	-	-	-		
1096	linalool	0.1	0.3	0.3	0.3	t	0.2	0.3	t	t		

Table 1. Continued

	7219	7217	7215	7211	7218	7210	7212	7213	7214
1102 isopentyl-isovalerate	-	0.2	0.2	0.0	-	0.1	-	-	0.2
1112 3-methyl-3-buten- methyl butanoate	0.3	0.5	0.2	0.1	t	t	0.1	0.2	0.2
1119 trans-p-menth-2-en-1-ol	t	0.2	0.1	t	t	t	-	-	-
1132 cis-limonene oxide	-	-	-	-	-	0.2	t	t	0.2
1133 cis-p-menth-2-en-1-ol	0.2	0.2	t	t	t	-	-	-	-
1137 trans-limonene oxide	t	0.1	0.1	0.1	t	0.1	t	t	0.2
1166 p-mentha-1,5-dien-8-ol	0.4	0.1	t	t	t	0.2	t	t	t
1174 terpinen-4-ol	1.1	2.5	2.4	0.4	0.3	0.4	0.2	t	t
1179 p-cymen-8-ol	0.3	t	t	t	-	t	-	-	-
1204 p-cymen-9-ol	0.2	0.2	t	t	-	t	-	-	-
1186 α-terpineol	0.2	0.4	0.8	0.2	0.1	0.2	0.5	0.6	0.6
1204 verbenone	-	-	-	-	-	t	-	-	-
1223 citronellol	-	-	-	-	-	t	-	-	-
1235 trans-chrysanthenyl acetate	-	-	-	-	-	0.2	-	-	-
1241 hexenyl isovalerate	0.3	0.3	0.2	0.3	0.1	-	-	-	-
1241 carvacrol, methyl ether	-	-	t	t	-	t	-	-	0.1
1249 piperitone	-	-	-	t	-	0.1	t	-	-
1254 linalyl acetate	0.2	0.3	0.5	0.2	-	-	-	-	-
1257 methyl citronellate	-	-	-	-	-	t	0.4	0.4	-
1274 pregeijerene B	3.5	4.0	4.9	t	t	0.5	-	0.3	0.3
1287 bornyl acetate	0.3	0.2	0.2	0.2	0.2	0.4	0.2	0.1	t

Table 1. Continued

	7219	7217	7215	7211	7218	7210	7212	7213	7214
1287 trans-linalool oxide acetate (pyranoid)									
1298 carvacrol	-	-	-	t	-	0.5	0.2	0.2	t
1339 trans-carvyl acetate	0.2	0.1	0.2	t	-	0.2	-	0.3	0.3
1345 α-cubebene	-	-	-	-	-	t	0.1	-	-
1346 α -terpinyl acetate	-	-	0.2	0.4	0.4	0.2	0.4	0.4	0.4
1374 α -copaene	-	-	-	0.2	-	-	-	-	-
1387 β-cubebene	-	-	0.1	0.2	0.1	0.2	0.2	-	0.2
1403 methyl eugenol	-	-	0.3	0.6	0.5	0.4	0.5	0.5	0.6
1417 (E)-caryophyllene	t	-	0.2	-	-	-	-	-	-
1448 cis-muurola-3,5-diene	t	-	0.3	0.2	0.1	0.3	0.3	t	0.2
1452 α -humulene	0.2	0.2	1.4	3.1	3.3	2.3	3.6	3.7	4.1
1461 cis-cadina-1(6),4-diene	-	t	0.2	0.3	t	0.2	0.3	t	0.3
1475 trans-cadina-1(6),4-diene	-	-	-	-	-	0.1	t	-	t
1478 γ -muurolene	t	t	t	0.1	t	t	t	t	t
1480 germacrene D	-	-	-	0.1	-	0.2	t	-	t
1493 trans-muurola-4(14),5-diene	0.1	-	2.8	5.8	8.9	6.5	9.3	9.6	10.9
1493 epi-cubebol	-	-	0.8	3.0	-	-	-	-	-
1500 α-muurolene	0.3	0.3	0.3	0.5	0.5	0.8	0.7	0.6	1.0
1513 γ -cadinene	0.6	0.3	0.9	3.0	3.0	0.6	0.7	0.5	0.6
1513 cubebol	-	0.3	1.8	6.8	5.9	5.4	6.1	4.9	5.5
1522 δ-cadinene	1.3	1.3	1.7	3.7	3.5	5.2	6.4	4.4	6.3

Table I. Continued

	7219	7217	7215	7211	7218	7210	7212	7213	7214
1528 zonarene	-	-	0.5	1.3	1.2	0.9	0.8	1.4	1.5
1533 trans-cadina-1,4-diene	-	0.2	0.2	0.6	0.6	0.5	0.6	0.6	0.7
1537 α -cadinene	-	-	0.1	0.2	-	t	t	-	0.1
1548 elemol	6.7	6.5	5.4	1.7	0.5	1.2	t	0.5	1.5
1559 cis-murol-5-en-5- α -ol	-	-	-	-	-	t	0.1	t	t
1559 germacrene B	0.3	0.3	0.2	0.1	-	-	-	-	-
1574 germacrene-D-4-ol	1.5	3.1	0.8	1.6	1.1	3.1	1.8	0.8	1.2
1582 caryophyllene oxide	t	-	t	0.1	t	t	t	-	-
1587 trans-murol-5-en-4- α -ol	t	-	0.3	3.3	2.2	1.1	1.3	0.5	0.7
1607 β-oplopenone	-	-	-	-	-	0.3	t	0.2	0.1
1608 humulene epoxide-II	0.1	0.3	t	0.3	0.2	-	-	-	-
1618 1,10-di-epi-cubenol	-	-	-	-	-	t	-	-	-
1627 1-epi-cubenol	-	-	1.9	5.8	4.5	3.2	3.6	3.2	3.9
1630 γ-eudesmol	1.5	1.0	1.2	0.5	t	0.1	-	-	-
1638 epi- α -cadinol	0.8	0.5	0.6	0.7	0.6	1.1	0.8	0.6	1.0
1638 epi- α -muurolol	0.8	0.5	0.5	0.8	0.5	1.0	0.8	0.6	1.0
1644 α -muurolol	t	t	t	0.3	t	0.3	0.2	t	0.2
1649 β -eudesmol	1.5	1.2	1.3	0.5	t	0.1	-	t	0.3
1652 α -eudesmol	1.0	0.7	0.9	0.7	0.3	1.2	0.6	0.4	0.9
1652 α -cadinol	1.0	0.7	1.0	0.7	0.4	1.1	0.6	0.5	0.9
1670 bulnesol	0.6	0.6	0.4	0.3	-	t	t	-	-

Table 1. Continued

	7219	7217	7215	7211	7218	7210	7212	7213	7214
1688 shyobunol	t	-	-	0.2	-	-	-	-	-
1792 8- α -acetoxycyclemol	2.9	2.5	2.3	t	-	0.4	-	t	0.2
2055 abietatriene	0.3	0.3	0.1	0.2	0.3	0.4	0.1	t	0.2
2056 manool	0.1	0.1	0.1	0.1	0.1	3.9	1.2	0.1	2.0
2087 abietadiene	2.3	1.0	1.8	0.5	0.3	1.4	0.2	t	t
2282 semperviroirol	t	-	-	0.1	-	-	-	-	-
2298 4-epi-abietal	0.1	0.1	-	0.8	0.3	0.3	0.2	t	0.2
2314 trans-totarol	0.5	0.8	0.3	0.9	0.3	0.2	0.2	t	0.5
2331 trans-ferruginol	-	-	-	t	-	-	-	-	-

**KEYS TO THE FLORA OF FLORIDA: 23,
OPUNTIA (CACTACEAE)**

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ABSTRACT

Opuntia (Cactaceae) is represented in Florida by 9 species, one of which has 2 varieties. All but one (*O. cochenillifera*) are native. Two species (*O. corallicola*, *O. triacantha*) are rated as endangered, one species (*O. stricta*) as threatened. Nine additional species have been reported for the state, but are believed not to persist outside of cultivation. An amplified key is given to the Florida taxa. *Phytologia* 91(3): 383-393 (December, 2009).

KEY WORDS: *Opuntia*, Cactaceae, Florida flora.

The genus *Opuntia* (Cactaceae) has many acquaintances but few friends. If the abundant needle-like spines did not inhibit close contact, the innumerable minute glochids served as a reminder that one intimate experience is sufficient. And even for the dedicated botanist, the fleshy pad-like stems invariably lose much of their diagnostic character when prepared for the herbarium. Thus, it is inevitable that only a few resolute students of the prickly pears would determine the species to be recognized and the features by which they are distinguished.

Four authors, in three major publications, have attempted to bring understanding to the Florida cacti. Nathaniel Lord Britton and James Nelson Rose produced an illustrated and descriptive study of the plants throughout the Americas (The Cactaceae. 1920). John Kunkel Small, a colleague and employee of Britton's, brought a close focus with detailed descriptions and keys to the cacti of the Southeast (Jour. N.Y. Bot. Gard. 22: 20-39. 1919; Manual S.E. Flora. 1933). Small

later expanded his floristic treatment by discussion of biogeographic implications (Jour. N.Y. Bot. Gard. 36: 1-11, 25-36, 1935). And Lyman Benson, a lifelong student of the family, duplicated and updated Britton & Rose's pioneer work (Cacti of the United States and Canada, 1982).

More recent studies have added detail in narrower fields: Barry L. Snow (Cactus & Succ. J. 53: 177-182, 1981), a history of the discovery and naming of southeastern cacti; and Daniel F. Austin, David M. Binniger & Donald J. Pinkava (Sida 18: 527-534, 1998), an analysis of the Florida semaphore cactus, *O. corallicola*. A thesis by J. D. Doyle (Univ. of North Carolina, 1990) has addressed the *O. humifusa* complex, though recognizing only a single taxon. Richard P. Wunderlin & Bruce F. Hansen (Guide to the Vascular Plants of Florida, 2003) have given a brief synopsis, closely patterned after Benson, of the Florida species.

The philosophies of Small and Benson, as measured by the numbers of species they recognized, could scarcely be more different. The indefatigable Small (1933) recorded 28 species within the state, while the California-based Benson (1982) found only 10. These differences are partly based on Small's practice of describing in detail and then naming as species each population he found to differ, while Benson treated Small's novelties as minor variations or hybrids unworthy of specific recognition.

But the time spent in the field by these two men was also very different. Small, for three decades, made almost annual trips to Florida, traveling throughout the state and studying its flora, while Benson is not documented as having made more than a single exploratory visit. Often Benson (1982) cited his examination of Small's own specimens (NY) as the basis for his assignment of taxa to hybrid status, not his own study of Florida populations. And Benson often included non-native species in the state, based solely on early Small collections, without himself having found them extant.

During the 1910s and 1920s Small and his friends gathered and cultivated numerous selections of *Opuntia* from throughout the state in the "cactus garden" of the Charles Deering estate, Dade Co. (See Small (1919) for photographs and descriptions made at "Buena Vista.") Small's observations of these plants, under uniform conditions of cultivation, give weight to the conclusions of his published studies.

But neither the detailed records of Small, nor the modern but abbreviated treatment by Benson (or the synopsis by Wunderlin & Hansen), permit a satisfying understanding of these Florida cacti. Perhaps the most disquieting indication to the visiting northern botanist that all is not yet resolved within Florida *Opuntia* is a visit to the quiet "pine islands" of the Ocala National Forest, in the north-central peninsula, where he sees sturdy tree-like cacti, to 1.5 meters or more in height, and is told that they are the same species as the obscure, wholly prostrate *O. humifusa* that he knew in the northern states.

This single observation is a direct introduction to the most intractable problem involving taxonomy of the Florida *Opuntia*. Within the Southeast the complex centered around *O. humifusa* was divided by Small into several species. *Opuntia humifusa* s.s. -- its type was from Kentucky -- is widespread across the northern states, but by Small was found to extend into the Southeast only along the Appalachian highlands. In contrast, on the southeastern and gulf coastal plains and across northern Florida, he recognized one widespread species, *O. pollardii*. (His *O. lata*, endemic to the lime sink region of northern peninsular Florida, appears indistinguishable.) Southward in the peninsula, Small encountered more variability. He found a tall plant, "with a stem 1-2 m. tall or more, becoming 1-2.5 dm. in diameter" (1919), best developed on the sands (now the Ocala National Forest) on the west side of Lake George, Volusia Co.; this he named *O. ammophila*. From the central peninsula southward, Small recognized something intermediate between *O. pollardii* and *O. ammophila*, with stems more diffused, not forming a trunk; he named it *O. austrina*.

Of these four taxa, Benson (1982) recognized three. He gave no consideration to the differences separating the coastal plain plant from the northern plant; he treated both as *O. humifusa*. But within Florida, though he seems to have had little understanding of *O. ammophila* (he limits its height to 30 cm.), he granted it varietal rank under *O. humifusa*. Likewise, separating *O. austrina* by its elongate joints, he accorded it similar varietal rank. (Wunderlin & Hansen (2003) were even less discerning. Under their aggregate *O. humifusa* they assigned 14 names, essentially folding all the variability reported by Small into a single undivided species.)

A modest transplant experiment has been run by the present author. In 2001, plants from a robust colony (Fort Wool, at the mouth of the James River, Eastern Virginia) of undoubted *O. humifusa* s.s. were transplanted to Florida (Alachua Co.) and placed among local plants identified as *O. pollardii*. Competition was avoided by regular weeding. Year by year the northern plants declined, first losing their few spines (the Florida plants were far more spiny), then their dark green coloration, then dying. None flowered nor fruited, nor produced any further joints. The last northern plant disappeared in 2008. The Florida plants prospered, in some years beset by woolly aphids, but flowering and fruiting annually.

The ease with which Benson (and others) has accepted the unity of the northern *O. humifusa* with the appreciably different coastal plain *O. pollardii* may lie in the similarity of the characteristic prostrate habit of *O. humifusa* with the prostrate or scarcely erect posture of young *O. pollardii*. If only vegetative characters are seen, the differences may be overlooked. The spines of *O. humifusa* are few or lacking (less than 1 cm. long) [vs. 2-3 cm. long with *O. pollardii*]. If leaves have not been shed, they are much smaller (2-3 mm. long) [vs. 6-8 mm. long]. Most striking, prostrate but mature plants of *O. humifusa* fruit abundantly, while young prostrate plants of *O. pollardii* never bear fruit. When present, the fruits of *O. humifusa* are significantly smaller (1-1.5 cm. long) [vs. 2-2.5 cm. long].

But even with *Opuntia pollardii*, adequately distinguished, the differences between that species and *O. ammophila* and *O. austrina* remain unclear. Solitary individuals may easily be mistaken one for the other. Indeed, with further study, specific rank may be found unmerited. But for the purposes of the field taxonomist, recognition of these taxa as discrete species seems preferable than to disregard their apparent differences.

All names used for Florida *Opuntia* have been addressed here, usually by assigning those thought to be redundant to the accepted species they most resemble. Clearly, if hybridization is present, such assignments are deceptive in part, for a second parent must also be involved. There is much room for future investigation, where close observation -- or controlled hybridization -- will permit more exact matching of these names with their true allegiances.

One name especially merits further examination. On the Middle Cape of Cape Sable, Monroe County, Small (1919) found a cactus with "finely banded" and "closely spirally twisted" spines; he appropriately named it *O. zebrina*. Benson (1982) has dismissed this as a synonym of *O. stricta* (as did Wunderlin & Hansen, 2003). But George Avery (pers. comm., Mar 1965) reported finding plants that matched Small's description on Big Pine, Boot, and Sugarloaf keys. One is always reluctant to accept species of the Keys as endemic, because of the brief time span the land has been emergent. But here, for simple convenience, *O. zebrina* is merely noted under *O. stricta* var. *dillenii*.

An issue has arisen that may well cast much of the present information regarding *Opuntia* into irrelevance. This is the appearance in Florida of an Argentine phycitine moth (*Cactoblastis cactorum*) whose larvae feed exclusively and voraciously on the larger plants of this genus (D. H. Habeck & F. D. Bennett, Ent. Circ. 333, Fla. Dept. Agric. & Cons. Serv. 1990). *Opuntia stricta*, once a common east coast species, is now greatly reduced, as are other Florida cacti, by the large orange and black larvae who burrow within the succulent pads and stems. Plants on Merritt Island, Brevard Co., seemingly little

afflicted in Feb 2000, were almost entirely destroyed by July 2000. Curiously, the fruits had matured and seemed normal even as the supporting pads were hollowed out by the rapacious larvae.

OPUNTIA Mill. ⁱ

1. Petals orange-yellow to bright red; plants erect, tree-like, much-branched; seeds with bristly hairs on side surfaces.
(subgen. **Consolea**)

2. Spines several per areole, diffusely spreading; petals small (1-1.5 cm. long), appressed to stamens, orange-yellow in bud, soon turning red; flowers ± 2 cm. dia. Erect tree-like shrub, to 3 m., with lateral spreading (semaphore-like) joints. Tropical hammocks. Florida Keys (Monroe Co. - Little Torch, formerly Key Largo, Big Pine); very rare (<12 plants in 1994). All year. Endemic. **ENDANGERED** (State listing). [*Consolea corallicola* Small; *Opuntia spinosissima*, misapplied]
FLORIDA SEMAPHORE CACTUS.

Opuntia corallicola (Small) Werderm. in Backeb.

2. Spines few or none; petals larger (2-2.5 cm. long), erect, bright red; flowers ± 3 cm. dia. Erect tree-like shrub, to 2 m. Dooryards, waste areas. South peninsula (north along east coast to Brevard Co. - Merritt Id.); rare. All year. Joints readily detach and become rooted. [*Nopalea cochenillifera* (L.) Salm-Dyck]
COCHINEAL CACTUS.

* **Opuntia cochenillifera** (L.) Mill.

1. Petals yellow; plants erect to decumbent or prostrate, relatively little branched; seeds without bristly hairs. (subgen. **Opuntia**)
3. Spines yellow, at least when young, stout (to 1.5 mm. thick).
4. Joints broad (6-12 cm. broad); mature spines terete at base, yellow until aged. Coastal dunes, shell middens. Robust erect or diffuse shrub, to 2 m. South and central peninsula (north to Nassau, Levy cos., disjunct to panhandle (Wakulla, Walton cos.)); formerly abundant. Spring-summer. Threatened (State listing). Once, the abundant fruits were an important food for the Florida natives. In the late 1990s the larvae of a foreign moth destroyed a great majority of this species (as well as other

species of *Opuntia*); only isolated plants now remain.
SHELL-MOUND PRICKLY PEAR, TUNA.

***Opuntia stricta* (Haw.) Haw.**

- a. Spines few. [*Opuntia Bentonii* Griffiths; *Opuntia keyensis* Britt. & Small] var. **stricta**

- a. Spines abundant, prominent. [*Opuntia atropicensis* Small; *Opuntia Dillenii* (Ker-Gawl.) Haw.; *Opuntia nitens* Small; *Opuntia tenuiflora* Small; *Opuntia tunoidea* Gibbs] *Opuntia zebrina* Small [spines banded], on the lower Keys, may be distinct. var. **dillenii** (Ker-Gawl.) Benson

4. Joints narrow (3-6 cm. broad); mature spines often flattened at base, gray in 2nd year (yellow when young). Low shrub, to 0.8 m. Openings and edges of tropical hammocks. Florida Keys (Monroe Co. - Big Pine, Ramrod, Grassy); rare. All year. [*Opuntia ochrocentra* Small in Britt. & Rose]

***Opuntia cubensis* Britt. & Rose**

3. Spines brown to gray, relatively slender (<1 mm. thick).

5. Joints (=pads or stem segments) readily detaching.

6. Joints elliptic to subcylindric (1.0-1.5 cm. broad); fruit with apex plane or shallowly concave. Prostrate creeping sub-shrub, to 0.1 m. Coastal dunes, dry pinelands. Panhandle coast (east to Jefferson Co.), disjunct to northeast Florida (Nassau to St. Johns cos.), further disjunct to lower gulf coast (Sarasota Co.); infrequent. Summer. The joints famously detach from the plant and adhere (via their retrorsely barbed spines) to innocent passers-by. [*Opuntia Drummondii* Graham; *Opuntia impedita* Small in Britt. & Rose; *Opuntia pisciformis* Small in Britt. & Rose; *Opuntia Tracyi* Britt.]

JOE-JUMPER.

***Opuntia pusilla* (Haw.) Haw.**

6. Joints obovate to suborbicular (3-4 cm. broad); fruit with apex (umbilicus) deeply concave. Prostrate shrub, to 0.2 m. Rocky hammocks. Florida Keys (Monroe Co. - Long, Big Pine); rare. Spring. ENDANGERED (State listing). [*Opuntia abjecta* Small in Britt. & Rose]

KEYS JOE-JUMPER. ***Opuntia triacantha* (Willd.) Sweet**

5. Joints firmly cohering.

7. Stem stiffly erect, lower trunk subcylindric and unbranched, branched above. Tree-like shrub, to 1.5 m. Dry pinelands, both Longleaf (*P. palustris*) and Sand Pine (*P. clausa*). Central peninsula (Marion, Lake - Ocala N.F.); locally freq. Spring. Endemic. [*Opuntia humifusa* (Raf.) Raf. var. *ammophila* (Small) Benson]

OCALA PRICKLY PEAR. ***Opuntia ammophila* Small**

7. Stem branched from base, not tree-like.

8. Joints elongate (length 2-3x width); stem sprawling, often ascending on adjacent vegetation. Sprawling or erect shrub, to 1 m. Thickets, brushy dunes, mangrove edges. South peninsula (north to Hillsborough, Brevard cos.); infrequent. Spring-summer. Endemic. [*Opuntia compressa* (Salisb.) Macbr. var. *austrina* (Small) Benson; *Opuntia cumulicola* Small; *Opuntia humifusa* (Raf.) Raf. var. *austrina* (Small) Dress; *Opuntia polycarpa* Small; *Opuntia turgida* Small in Britt. & Rose] A catch-all taxon, very probably including numerous hybrids.

HAMMOCK PRICKLY PEAR. ***Opuntia austrina* Small**

8. Joints broadly orbicular to obovate (length 1.2-1.8x width); stem prostrate or briefly ascending. Semi-prostrate to spreading shrub, to 0.3 m. Sandy waste areas, roadbanks, dry pastures. Panhandle and north Florida, south to mid-peninsula (Highlands Co.); common. Spring-summer. [*Opuntia lata* Small]

COASTAL PLAIN PRICKLY PEAR.

***Opuntia pollardii* Britt. & Rose**

Excluded names:

Opuntia brasiliensis (Willd.) Haw.

Brasilopuntia brasiliensis (Willd.) Berger

Distinctive "polelike trees." Reported by Britton & Rose (1919) who noted, "Dr. Small has found this plant established after planting on shell mounds and waste places in southern Florida"; by Small (1919), to "5 m. tall or more," from "woods, eastern peninsular Florida," specifically from "a shell mound south of Daytona," Volusia Co.; and by Long & Lakela (1972). Small's identification of this distinctive non-native species was probably correct, though no specimen was preserved. But the plants, as well as habitat, are long gone. The photos of Britton & Rose were of Cuban plants.

Opuntia eburnispina Small in Britt. & Rose

A Cape Romano, Monroe Co., plant, apparently not re-collected (Britton & Rose, 1923; Small, 1933). Perhaps close to *O. cubensis*. Benson (1982) suggested it to be a hybrid involving *O. humifusa* (= *O. austrina*?) or perhaps *O. stricta*, though the similarities are not apparent.

Opuntia ficus-indica (L.) Mill. Indian Fig

Reported as naturalized by Small (1919; 1933), and by Wunderlin (1998). Widely cultivated as a door-yard novelty and persisting short-term. The fruits are abundant and are often scattered, but seedlings have not been reported, and the pads do not detach readily. No naturalized populations are known.

Opuntia humifusa (Raf.) Raf. Northern Prickly Pear

Opuntia compressa (Salisb.) Macbr.

Opuntia Opuntia (L.) Karst.

Exclusion of this northern species from Florida is dependent upon the judgment that plants of typical *O. humifusa* do not occur within the state, most plants so assigned being the more robust, upright, larger-fruited *O. pollardii*. Dress (1975) pointed out that Salisbury's basionym is superfluous, and that *O. humifusa*, though later, is correct.

Opuntia leucotricha DC. Aaron's-beard Cactus

Reported by Small (1925; 1933) as naturalized near Rio, south of Ft. Pierce, Martin Co., with the suggestion it was introduced by "pioneers during Seminole War times." Benson (1982) confirmed

Small's spm., as collected in 1918. Retained by Wunderlin (1998), without further data. The station has long since been obliterated by development.

***Opuntia lindheimeri* Engelm.**

A western species, perhaps once introduced. Small (1927; 1933) reported it west of Hallandale, Broward Co., "especially about old settlements and homesteads." Not seen by later observers.

***Opuntia magnifica* Small**

Described by Small (1925) from the south end of Amelia Id., Nassau Co. A large plant, to 2 m. in height, with very slender, flexible spines. Small suspected it to be an introduction, but Benson (1982) placed it with *O. stricta*. Not found in recent search.

***Opuntia turbinata* Small**

Described by Small (1933) from Ft. George Id., Duval Co. Benson (1982) indirectly placed it with *O. stricta* var. *dillenii*. But the small, near-globose berries suggest some other alliance. Apparently never recollected.

***Opuntia vulgaris* Mill.**

Opuntia monacantha (Willd.) Haw.

South American; reported by Benson (1982) as introduced in Polk (Crooked Lake, Lake Alfred) and Highlands cos., but only as hybrids with *O. ammophila*. Since *O. vulgaris* itself is unknown in the state, a correct identification (from herbarium materials!) is unlikely.

i. This paper is a continuation of a series begun in 1977. The "amplified key" format employed here is designed to present in compact form the basic morphological framework of a conventional dichotomous key, as well as data on habitat, range, and frequency. Amplified keys are being prepared for all genera of the Florida vascular flora; the present series is restricted to genera where a new combination is required or a special situation merits extended discussion.

CONVOLVULUS CARRII, A LOCALIZED ENDEMIC FROM SOUTHERNMOST TEXAS

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ABSTRACT

A new *Convolvulus* species is described from fine Holocene sands in southern Texas: *Convolvulus carriei* B. L. Turner, **sp. nov.** The ecology and possible speciation is discussed. *Phytologia* 91(3): 394-400 (December, 2009).

KEY WORDS: *Convolvulus carriei*, *Convolvulus equitans*, taxonomy.

Routine identification of Texas plants has revealed the following novelty:

CONVOLVULUS CARRII B.L. Turner, **sp. nov.** Figs. 1, 2

Convolvulus equitanti Benth., similis sed differt foliis incrassatis valde venosis dense argento-pilosis et seminibus laevibus vel paene laevibus (vs papillosis).

Prostrate perennial or twining vine. **Stems** densely pilose with silvery hairs, the vestiture ca 1 mm high. **Leaves** 3-7 cm long, 2-3 cm wide, pubescent like the stems; petioles 1.0-2.5 cm long; blades thickened subhastate to subcordate, markedly venose, the margins irregularly dentate. **Flowers** mostly solitary (rarely not) on bracteate peduncles 5-7 cm long. **Sepals** 5, subequal, 9-11 mm long, their apices broadly rounded and minutely apiculate. **Corollas** white, ca 3 cm long, ca 4 cm across the extended petals, the throat "maroon" or wine-colored," occasionally not. **Stamens** 5, the anthers ca 4 mm long. **Styles** ca 2 cm long; the shafts glabrous, or rarely pilose at the apex

(Correll & Correll 38844), the linear branches ca 2 mm long. **Seeds** 3-5 mm long, ca 2mm wide, smooth or nearly so.

TYPE: U.S.A. TEXAS: HIDALGO Co., East side of Hwy 181, 7 mi N of San Miguel in deep, finely grained, white-sandy soils.

Prostrate perennials arising from ligneous roots, the stems up to 8 ft long; corollas white with a purple eye at base of throat. At least 6 very uniform populations were seen over a ½ mi stretch of the highway (6.5-7.0 mi N of San Miguel), 20 Apr 2009, *Billie L. Turner & Jana Kos 09-03* (Holotype: TEX; isotypes, to be distributed).

After the above observations, my colleagues, Richardson and King visited the type locale a second time and noted that while most of the populations had the typical purple centers, "2 or 3 of them had much smaller purple centers, and 3 or 4 of them were all white." Nevertheless, the syndrome of characters (described below) appears to hold for most of the populations concerned, and I still believe the taxon worthy of specific rank, the character perturbations notwithstanding.

ADDITIONAL SPECIMENS EXAMINED: U.S.A.: Brooks Co., S side of R. M. 755, ca 3.6 road-miles NE of Starr County line, "locally common in sparse vegetation on fine sand...on level upland underlain by eolian sand of Holocene," 26 47 45.4 N, 98 23 31.9 W, 230-240 ft, 9 Apr 2008, *W.R. Carr 26646* [with D. Benish] (TEX); several mi SE of Falfurrias, "near gypsum quarry," 10 Jul 1957, *Correll & I.M. Johnston 17811* (LL); 6 mi S of Falfurrias, 4 Jun 1970, *D.S. & Helen Correll 38884* (LL). **Hidalgo Co.,** northern part of county along highway 281, 15 Oct 2005, *Richardson & King 3337* (TEX); "Hwy 281, northbound, 7.0 miles north of intersection with hwy 186," 15 Nov 2008, *Richardson & King 3397* (TEX); same as previous location, 22 Mar 2009, *Richardson & King 3405* (TEX); "north edge of Hidalgo Co.," 16 Jul 1925, *Runyon 890* (TEX); near San Manuel along highway 281, 4 May 1941, *Runyon 2627* (TEX).

The novelty is closely similar to *Convolvulus equitans* but can be distinguished by a syndrome of characters, including thickened, markedly venose, silvery-pubescent, markedly dentate, deltoid leaves (vs thin, sparsely pubescent, and highly variable as to shape and marginal dentation); flowering peduncles 5-7 cm long (vs. shorter);

large white corollas with maroon or purplish throats, rarely not (vs. smaller and white to pale pink, the purple throats only rarely present); and seed coats smooth or nearly so (vs. mostly papillose). The smooth seeds of *C. carrii* are especially striking, this not observed in the large number of collections of *C. equitans* from southern-most Texas on file at LL-TEX, although nearly smooth seeds may occur elsewhere over the range of the species.

Because of the extraordinary fact that only two species of *Convolvulus* are native to North America, one reviewer of the present paper suggested that *C. carrii* might be an introduced species, either of *Convolvulus* or the closely related *Calystegia*. The relatively large flowers suggest the latter, but the slender style branches and yet other characters are clearly those of *Convolvulus*. Indeed, Correll, Runyon, and yet other knowledgeable taxonomists, have identified the plants concerned as *C. equitans*, in spite of the combination of characters that mark the species.

Might the taxon be an exotic introduction to southern Texas? Not, in my opinion, since it is confined to a particular sand type, and is remarkably uniform from population to population over the area concerned. I have also examined a large suite of specimens of *Convolvulus* and *Calystegia* from throughout the world on file at LL-TEX and could detect no close fits.

My own conjecture as to its origin follows: the fine Holocene sands, to which it seems confined, are derived from ancestral dunes, estimated at ca 10,000 years old (Carr, 2009). Over this time the characters of *C. carrii* must have evolved out of the more widespread, highly variable *C. equitans*. In short, a combination of characters selected out of *C. equitans*, with the evolution of yet others affecting its reproductive success, led to its existence. Verification must await DNA and experimental studies.

According to label-data (Carr 26646), and personal observation, *C. carrii* is a prostrate perennial or else found "climbing over shrubs" (Correll & Johnston 17811). Carr states that the taxon is locally common on deep eolian sands of the Holocene.

The type locality site was called to my attention by Al Richardson, for which I am most grateful. In spite of the seemingly regional drought at the time, plants at this locality were vigorous and in full flower. Interestingly, no plants of *C. equitans* were found in the deep sandy soils to which *C. carrii* is restricted, although it is exceedingly common elsewhere in the state of Texas and Mexico (Figs. 2, 3). Similar sandy soils of the Holocene reportedly occur in adjacent Kenedy Co., and it is likely that the novelty will be found to occur in that area as well.

The novelty is named for William R. Carr, exceptional botanical systematist working for the Nature Conservancy of Texas, who first called my attention to the plants concerned.

ACKNOWLEDGEMENTS

I am grateful to Guy Nesom for the Latin diagnosis; he also reviewed the paper, for which I am grateful. Al Richardson, My Academic Son (having obtained his doctorate under my supervision in 1975) and his close field companion, Ken King, provided considerable input into the venture, especially in the procurement of mature seeds. Jana Kos was a field companion during my own study of the plants concerned, having to tolerate an excess of ohs and ahs upon seeing this or that population.

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Fig. 1. *Convolvulus carrii* (holotype).



Fig. 2. Field plants of *C. carrii* (Carr 26646, TEX).

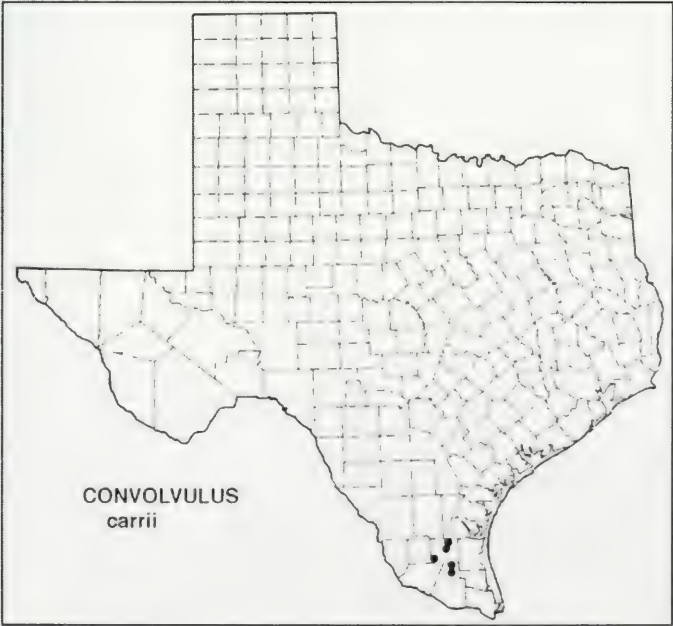


Fig. 3. Distribution of *C. carrii*.

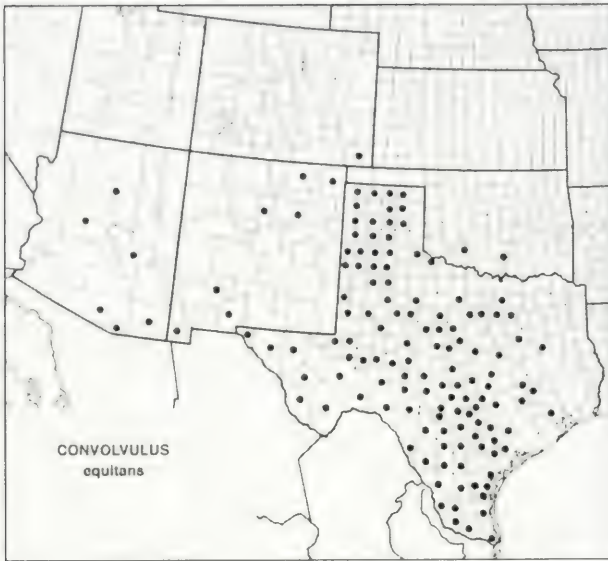


Fig. 4. Distribution of *C. equitans* in Texas (based upon specimens at SRSC and LL-TEX).

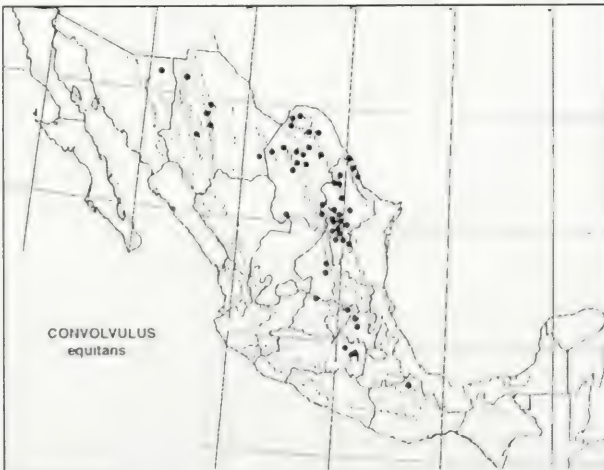


Fig. 5. Distribution of *C. equitans* in Mexico (based upon specimens at LL-TEX).

**COMPOSITION AND STRUCTURE OF THE GROUND LAYER
VEGETATION AT IROQUOIS COUNTY CONSERVATION
AREA, NORTHEASTERN ILLINOIS**

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ABSTRACT

The 7.8 km² Iroquois County Conservation Area in northeastern Illinois contains many of the plant communities found at this site during pre-settlement times. A sedge meadow, about 2.5 km² in size was dominated by *Carex haydenii/stricta*. The shrub sand prairie was dominated by *Carex haydenii/stricta*, but nearly 50 species encountered in the plots. In the wet-mesic sand prairies, *Rubus hispidus*, *Euthamia graminifolia*, *Potentilla simplex* and *Sorghastrum nutans* dominated, while in the dry-mesic sand prairies *Rubus hispidus*, *Schizachyrium scoparium*, *Vaccinium angustifolium* and *Sorghastrum nutans* were dominant. The ground layer vegetation of the sand flatwood communities was sparse with few species present, *Vaccinium angustifolium* and *Carex haydenii* being the most common. The sand savanna communities associated with the dunes had high species diversity. Here the ground layer vegetation varied, depending upon available moisture and shading. In the dry-mesic sand savanna *Vaccinium angustifolium*, *Pteridium aquilinum* and *Carex pensylvanica* were dominant, while in the dry sand savanna *Carex pensylvanica*, *Rhus copallina*, *Rubus allegheniensis* and *Schizachyrium scoparium* were the important species. This base line data will be used to determine management practices on the conservation area and surrounding nature preserves. *Phytologia* 91(3) 401-438 (December, 2009).

KEY WORDS: Vegetation, Iroquois County Conservation Area, Illinois, ecology, plant communities.

At the time of European settlement prairie vegetation covered about 60% of Illinois (Iverson et al. 1991). Most was "black soil" tall-grass prairie of the prairie peninsula (Transeau 1935), though sand prairies were relatively common (Schwegman 1973). These sand prairies occur in the northern half of Illinois on glacial outwash plains associated with erosional events of Wisconsin glaciation (Willman and Frye 1970, King 1981). One of the most extensive in the state is the Kankakee sand deposit in northeastern Illinois in parts of Iroquois and Kankakee counties and adjacent Newton County, Indiana.

Until relatively recently, no detailed studies of the vegetation of the Kankakee sand deposits had been undertaken. The pre-settlement vegetation of Iroquois County was studied by Hedborn (1984) while McDowell et al. (1983) described the composition and structure of the savanna communities of the Iroquois County Conservation Area. More recently, Johnson and Ebinger (1992, 1995) studied the effects of fire on the vegetation of the sand savannas at Hooper Branch Nature Preserve, Iroquois County, Illinois. The present study was undertaken to determine vascular plant species composition and structure, and the floristic quality of the ground layer vegetation of the major plant communities at the Iroquois County Conservation Area (ICCA).

DESCRIPTION OF THE STUDY SITE

The ICCA, which encompasses 7.8 km², is located in extreme northeastern Iroquois County about 6 km northeast of the town of Beaverville (S22, 23, 24 T29N R11W) in the Kankakee Sand Area Section of the Grand Prairie Natural Division of Illinois (Schwegman 1973)(Figure 1). Purchased by the Illinois Department of Conservation in 1944 as a prairie chicken sanctuary, the ICCA is now used principally as a hunting area, particularly a permit pheasant hunting area. When purchased most of the area had been heavily grazed and attempts had been made to drain the sedge meadow and marsh communities (White and Madany, 1978).

The ICCA is situated at the edge of former glacial Lake Watseka, drained about 14,500 years ago during the Kankakee Torrent, leaving sandy beaches and near shore sand deposits (Willman 1973). These sands were reworked by wind, creating the dune and swale

topography present today. The characteristic sand savanna, sand prairie, and sedge meadow vegetation became established during the Hypsithermal period about 8,000 years ago (King 1981). The soils of the ICCA are not diverse (Wascher et al. 1951, Kiefer 1982). The marshes, sedge meadows, shrub prairies, wet-mesic sand prairies, and flatwood communities that occur in depressions between the dunes are situated on Watseka loamy sands, Granby fine sandy loams, and Moracco fine sands. These soils, derived from sandy outwash sediments, are acid, peaty sand with a dark-brown to black surface horizon that are poorly drained. The soils on the dunes are Oakville fine sands that developed from sandy sediments that have a dark grayish brown surface horizon and are well drained (Kiefer 1982).

Climate at the ICCA is continental with warm summers and cold winters. Based on weather data from Kankakee, 30 km to the northwest, mean annual precipitation is 98.0 cm, with May having the highest rainfall (11.5 cm). Mean annual temperature is 9.9°C with the hottest month being July (average of 23.6°C), and the coldest January (average of -5.7°C). Frost free days range from 141 to 206, with the average being 174 days per year (Midwestern Regional Climate Center 2007).

MATERIALS AND METHODS

During the growing seasons of 2000 through 2003 the ICCA was visited numerous times, although many trips dating back to 1970 were made by one of the authors (JEE). On the trips the plants species encountered were collected, their habitat recorded, and voucher specimens deposited in the Stover-Ebinger Herbarium of Eastern Illinois University, Charleston, Illinois (EIU), or the herbarium of the Illinois Natural History Survey, Champaign, Illinois (ILLS). Criteria for designating non-native species followed Mohlenbrock (2002), and Gleason and Cronquist (1991). Nomenclature follows Mohlenbrock (2002) while Herkert and Ebinger (2002) was used for listing the Illinois endangered and threatened species.

Between 2001 and 2003 the ground layer vegetation of the major plant communities found at the ICCA was sampled by randomly locating two to four 25m transects throughout the best quality example

of each community type (White and Madany 1978). Along each transect m² plots were located at 1 m intervals (n=25/transect), odd-numbered plots to the right, even-numbered to the left. A random numbers table (0-9) was used to determine the number of m the plot was placed from the transect line. Cover of each species was determined using the Daubenmire cover class system (Daubenmire 1959) as modified by Bailey and Poulton (1968). Importance value (IV) was determined by summing relative cover and relative frequency.

The Sorensen Index of Similarity (ISs) was used to determine the degree of vegetation similarity between the areas surveyed throughout the ICCA (Mueller-Dombois and Ellenberg 1974). This index utilizes binary data (presence/absence) to measure the similarity in species composition between sites and is represented by the following equation: $[ISs = 2C/A+B \times 100]$, A equals the number of species in the first community, B equals the number of species in the second community, and C equals the number of species common between the two communities. Pairwise comparisons were made between each of the seven community types.

RESULTS

Floristic Assessment: A total of 562 taxa representing 303 genera and 97 families were documented for the ICCA (Appendix I). Fern, fern-allies and gymnosperms were represented by 17 taxa in 10 families. Of the remainder, 155 were monocots in 17 families and 72 genera, and 390 were dicots in 70 families and 220 genera. Of this total 78 non-native species were encountered (14% of all taxa), mostly in disturbed habitats. The predominant plant families were the Asteraceae with 79 taxa, the Poaceae with 67 taxa, and the Cyperaceae with 49 taxa. State endangered taxa included *Carex cumulata*, *Carex physorhyncha*, *Hypericum adpressum*, *Persicaria careyi*, *Scleria pauciflora*, *Vaccinium corymbosum*, and *Viola primulifolia* were vouchered as were the state threatened *Drosera intermedia*, *Hymenopappus scabiosaeus*, *Platanthera flava* var. *herbiola*, *Rubus schneideri*, *Sisyrinchium atlanticum* and *Veronica scutellata* (Herkert and Ebinger 2002).

Marsh: The marsh community at the ICCA was extremely small, degraded, and retained little of the original natural quality. When first observed in 1983 by one of the authors (JEE), four vegetation zones were present in this marsh: *Typha latifolia* zone; *Shoenoplectus tabernaemontani* zone; *Bolboschoenus fluviatilis* zone; and a mixed vegetation zone. The mixed vegetation zone lacked a major dominant with *Glyceria septentrionalis*, *Veronica scutellata*, *Thelypteris palustris*, *Spartina pectinata*, and *Persicaria hydropiper* dominating this zone. The other zones were dominated by a single species, few other taxa were present. Presently, due to the lowering of the water table, few of the marsh species are present at this site and the entire area is overgrown with *Phalaris arundinacea*. This area was not surveyed during the present study.

Sedge Meadow: Very homogeneous in structure and relatively low in species diversity, the sedge meadows had well developed hummocks created by the dominant species *Carex stricta* and *C. haydenii* (IV of 113 out of 200). Both species were common, and as they were not blooming when the survey was conducted, no attempt was made to distinguish them (Table 1). Some small sedge meadows were present at the ICCA, occurring in the areas between the dunes. In addition, a 2.5 km² sedge meadow exists in the southwestern quarter of the ICCA and was the one surveyed during the present study. Besides *Carex stricta/haydenii*, only two species were relatively common, *Calamagrostis canadensis* and *Persicaria coccinea*. Only 29 species were encountered in the plots, more than half with IVs of less than 1.0 (Table 1).

Shrub Sand Prairie: Only a few small examples of this community type were found at the ICCA. The ground layer of the wet-mesic shrub prairie was dominated by *Carex stricta/haydenii* (IV of 19.7) followed by *Potentilla simplex* (18.8), *Spiraea tomentosa* (14.7), *Euthamia graminifolia* (13.1), *Rubus hispidus* (12.5), *Schizachyrium scoparium* (10.8) and *Liatris spicata* (10.3) (Table 1). This community had high species diversity with 52 taxa recorded in the plots.

Wet-mesic Sand Prairie: A few wet-mesic sand prairies occurred at the ICCA, most being located adjacent to the sedge meadow community but on slightly higher ground. All of the wet-mesic prairies

examined show indications of disturbance, but species diversity was relatively high with 42 taxa occurring in the plots (Table 2). Eight species had IVs exceeding 10.0; *Rubus hispidus* (IV of 20.1), *Euthamia graminifolia* (18.3), *Potentilla simplex* (18.2), and *Sorghastrum nutans* (18.1) being the most important (Table 2).

Dry-mesic Sand Prairie: Few examples of this community were found, the only one large enough to study was located along the north edge of the ICCA. At this site, located on a lower dune slope, *Rubus hispidus* (IV of 32.8) and *Schizachyrium scoparium* dominated (31.3) followed by *Vaccinium angustifolium* (22.4), *Sorghastrum nutans* (13.3), *Aster simplex* (13.1), and *Carex pensylvanica* (13.1) with 30 other taxa found in the plots (Table 2).

Sand Flatwoods: A few small flatwoods communities occurred on the ICCA, all in depressions between dunes. *Quercus palustris* dominated the overstory of these flatwoods. The ground layer vegetation was sparse and much of the area lacked vegetation altogether as indicated by the average bare ground and litter being 87.10% (Table 1). Common species encountered were *Vaccinium angustifolium*, *Carex stricta/haydenii*, and *Rubus hispidus* with only 12 other taxa in the plots (Table 1).

Dry-mesic Sand Savanna: This community was relatively common on the lower slopes of the many dunes at the ICCA, some being of high natural quality. In this community *Quercus velutina* was the dominant overstory species but *Quercus alba* was also present, accounting for one-third to nearly half of the IV. The ground layer of this community was extremely variable depending upon past disturbances, time since the last fire, and the extent of shading. The present survey was undertaken in a dry-mesic sand savanna that had been burned in the fall of 2001 (two years prior to the survey), creating an open understory. *Vaccinium angustifolium* was the dominant species with an IV of 43.7, followed by *Pteridium aquilinum* (29.2), and *Carex pensylvanica* (24.6). Numerous seedlings of *Quercus velutina* and *Q. alba* were present accounting for these species being fourth and fifth in IV. Also various species of shrubs were common, mostly sprouts from individuals that had been top-killed by the fire (Table 3).

Dry Sand Savanna: Common on the ridges and upper slopes of the many dunes, this community was dominated by *Quercus velutina* to the almost total exclusion of other tree species. *Carex pensylvanica* (IV of 27.7) and *Schizachyrium scoparium* (13.2) were the dominant herbaceous species. Shrubs and tree seedlings were also important in the ground layer, *Rhus copallina* (24.4), *Rubus allegheniensis* (22.1) and *Quercus velutina* (12.5) were among the top five species in IV (Table 3). The ground layer of this community was diverse with 52 taxa recorded for the plots.

Sorensen Index of Similarities: The communities studied were dominated by sand prairie species with as many as 15 species in common (Table 4). The wet-mesic and dry-mesic sand prairies had relatively high species similarity (ISs = 43.59), and were similar in species composition to the sand shrub prairie (ISs = 46.80 and 50.00, respectively). Most of the communities examined show little similarity to the sedge meadow, the highest being the shrub prairie (Table 4). We expected that the dry-mesic and dry savanna would have similar species composition and a relatively high similarity index. The dry-mesic sand savanna, however, was located near the base of a dune, the soil being slightly organic. Many of the species encountered in this dry-mesic savanna were associated with the ground layer vegetation of sand flatwoods.

DISCUSSION

The ICCA contained good quality examples of many of the sand communities that are known to occur in Illinois (McDowell et al. 1983). Some of these communities are large, the sedge meadow exceeds about 2.5 km², the dry and dry-mesic savanna exceeds 2 km². Based on the surveys results, species richness was high, few exotic species were encountered in the high quality natural areas of the ICCA, and 13 Illinois endangered and threatened species were vouchered. In the communities studied sand prairie species dominated, and usually with as many as 15 species in common (Table 4).

Though 78 non-native (exotic) taxa were collected on the ICCA, few were encountered in the natural communities. Most were found along the road on the south, west, and north sides of the ICCA,

on trails and dirt roads throughout the ICCA, or in the cultural areas associated with food plots, staging areas, and roadside parking areas associated with the hunting activities at the ICCA. Among the non-native species that were found in the natural communities, *Poa pratensis* was the most common, being encountered in the sedge meadow (IV of 0.3), wet-mesic sand prairie (2.7), and dry mesic sand prairie (1.1). Other non-native species found in a few communities with very low IVs included *Achillea millefolium* and *Rumex acetosella*. In other glacial sand deposits of Illinois similar results were encountered with one to four exotics species found, most with low importance values (Handel et al. 2003; Phillippe et al. 2004, 2008; McClain et al. 2005, 2008; Ebinger et al. 2006)

The size of the ICCA, and the many examples of these communities, should allow different management practices to be tested. The present management consists of occasional burns (Johnson and Ebinger 1992, 1995). These have been sufficient to keep the dry sand savanna communities open, but have not been sufficient to keep most of the tree saplings from stump sprouting and shading the ground layer vegetation (McDowell et al. 1983). Also, the sand prairie communities have numerous tree seedlings and saplings and the size of the communities are becoming smaller due to the shade of surrounding trees. Fire frequencies should be increased, and possibly the season of the year that fire is used should be varied.

Probably the major problem now facing the ICCA is the loss of ground water due to draining efforts on the surrounding farmland and the increased use of central pivot irrigation systems. Drainage ditches are presently along the east boundary of the preserve and in the southwest corner. The de-watering of the site by these ditches has resulted in the loss of the marsh communities along the east edge of the ICCA. Also, the large sedge meadow in the southwestern part of the preserve is becoming drier, with the potential loss of some of the typical wetland species.

ACKNOWLEDGMENTS

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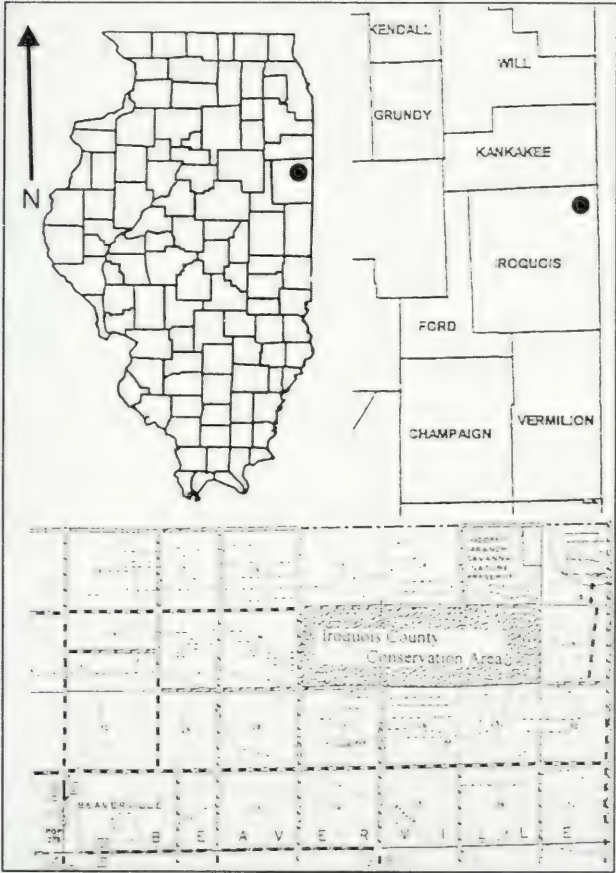


Figure 1. Location of Iroquois County Conservation Area located about 6 km northeast of the town of Beaverville, Iroquois County, Illinois.

Table 1. Frequency (%), mean cover (% of total) and importance value (I.V.) of the ground layer species encountered in the sedge meadow, shrub prairie, and sand flatwoods, Iroquois County Conservation Area, Illinois. Also given for each site is the total number of species encountered in the plots and the average number of species per plot. *Others category. Include species with IVs less than 3.0.

Species	Sedge Meadow			Shrub Prairie			Sand Flatwoods		
	Freq. %	Mean cover	I.V.	Freq. %	Mean Cover	I.V.	Freq. %	Mean Cover	I.V.
<i>Carex stricta/haydenii</i>	100	78.55	113.4	98	20.23	19.7	22	1.29	29.5
<i>Potentilla simplex</i>	--	--	--	94	19.30	18.8	--	--	--
<i>Spiraea tomentosa</i>	--	--	--	94	12.89	14.7	--	--	--
<i>Euthamia graminifolia</i>	1	0.01	0.3	96	10.00	13.1	--	--	--
<i>Rubus hispida</i>	--	--	--	72	11.66	12.5	16	1.21	24.6
<i>Schizachyrium scoparium</i>	--	--	--	62	10.26	10.8	--	--	--
<i>Liatris spicata</i>	--	--	--	68	8.70	10.3	--	--	--
<i>Calamagrostis canadensis</i>	52	4.52	18.6	48	9.89	9.6	--	--	--
<i>Spartina pectinata</i>	6	0.31	1.9	52	8.13	8.7	--	--	--
<i>Sorghastrum nutans</i>	--	--	--	50	8.02	8.6	--	--	--
<i>Solidago gigantea</i>	2	0.04	0.6	54	3.68	6.1	--	--	--
<i>Viola primulifolia</i>	--	--	--	46	4.03	5.7	--	--	--
<i>Baptisia alba</i>	--	--	--	22	6.00	5.3	--	--	--
<i>Lysimachia lanceolata</i>	--	--	--	56	2.04	5.2	--	--	--
<i>Viola lanceolata</i>	--	--	--	56	1.70	5.0	6	0.08	4.9
<i>Polygala cruciata</i>	--	--	--	58	0.59	4.5	--	--	--
<i>Solidago nemoralis</i>	--	--	--	24	3.70	4.0	--	--	--
<i>Andropogon gerardii</i>	--	--	--	28	2.73	3.7	--	--	--
<i>Eryngium yuccifolium</i>	--	--	--	18	3.59	3.6	--	--	--
<i>Conocarpus tripteris</i>	--	--	--	32	1.58	3.3	--	--	--
<i>Vernonia gigantea</i>	--	--	--	32	1.19	3.1	--	--	--
<i>Solidago canadensis</i>	--	--	--	32	1.05	3.0	--	--	--

<i>Persicaria coccinea</i>	57	1.33	16.5	--	--	--	--	--	--
<i>Carex buxbaumii</i>	33	0.73	9.5	--	--	--	--	--	--
<i>Galium obtusum</i>	31	1.04	9.4	18	0.19	1.4	--	--	--
<i>Hypericum sphaerocarpum</i>	23	1.77	8.1	--	--	--	--	--	--
<i>Lycopus americanus</i>	16	0.10	4.3	--	--	--	--	--	--
<i>Eleocharis verrucosa</i>	15	0.12	4.0	16	0.08	1.2	--	--	--
<i>Vaccinium angustifolium</i>	--	--	--	14	1.59	2.0	20	2.76	45.1
<i>Aronia melanocarpa</i>	--	--	--	6	0.42	0.7	12	1.03	19.9
<i>Quercus palustris</i>	--	--	--	8	0.48	0.9	20	0.35	17.3
<i>Dichanthelium acuminatum</i>	--	--	--	--	--	--	12	0.79	17.1
<i>Drosera intermedia</i>	--	--	--	2	0.06	0.1	12	0.74	16.5
<i>Sassafras albidum</i>	--	--	--	--	--	--	10	0.05	7.3
<i>Carex pensylvanica</i>	--	--	--	--	--	--	4	0.31	6.3
<i>Rhynchospora capitellata</i>	--	--	--	2	0.01	0.1	6	0.03	4.4
Others*	--	1.58	13.4	--	4.86	14.3	--	0.05	7.1
Totals		90.10	200.0		158.65	200.0		8.69	200.0
Average bare ground/litter		7.96			6.96			87.10	
Total species in plots	29		52				15		
Average species/plots	3.83		14.26				1.50		

Table 2. Frequency (%), mean cover (% of total) and importance value (I.V.) of the ground layer species encountered in the wet-mesic sand prairie and the dry-mesic sand prairie, Iroquois County Conservation Area, Illinois. Also given for each site is the total number of species encountered in the plots and the average number of species per plot.

*Others category Include species with IVs less than 2.0.

Species	Wet-mesic Sand Prairie			Dry-mesic Sand Prairie		
	Freq. %	Mean Cover	I.V.	Freq. %	Mean Cover	I.V.
<i>Rubus hispidus</i>	92	22.90	20.1	100	16.72	32.8
<i>Euthamia graminifolia</i>	98	18.69	18.3	50	2.06	8.0
<i>Potentilla simplex</i>	98	18.57	18.2	58	1.14	7.7
<i>Sorghastrum nutans</i>	84	20.26	18.1	72	4.32	13.3
<i>Rubus schneideri</i>	84	16.84	15.8	--	--	--
<i>Carex pensylvanica</i>	98	11.71	14.2	70	4.36	13.1
<i>Schizachyrium scoparium</i>	84	12.87	13.8	92	16.43	31.3
<i>Solidago canadensis</i>	78	9.59	11.5	--	--	--
<i>Liatris spicata</i>	52	8.58	8.9	--	--	--
<i>Spiraea tomentosa</i>	66	5.85	8.4	--	--	--
<i>Coreopsis tripteris</i>	42	5.26	6.3	--	--	--
<i>Solidago gigantea</i>	56	2.74	6.0	--	--	--
<i>Bartonia virginica</i>	46	0.23	3.6	--	--	--
<i>Pycnanthemum virginianum</i>	30	1.28	3.0	--	--	--
<i>Andropogon gerardii</i>	18	2.69	3.0	26	1.30	4.5
<i>Poa pratensis</i>	28	0.97	2.7	--	--	--
<i>Spiraea alba</i>	30	0.75	2.7	--	--	--
<i>Panicum virgatum</i>	22	1.14	2.4	28	1.75	5.3
<i>Spartina pectinata</i>	24	1.10	2.4	--	--	--
<i>Aronia melanocarpa</i>	10	2.66	2.3	--	--	--
<i>Achillea millefolium</i>	24	0.66	2.2	--	--	--
<i>Galium obtusum</i>	22	0.55	2.0	--	--	--
<i>Vaccinium angustifolium</i>	--	--	--	40	13.89	22.4
<i>Aster simplex</i>	14	0.61	1.5	82	3.35	13.1

<i>Scleria triglomerata</i>	--	--	--	56	1.43	7.8
<i>Salix humilis</i>	--	--	--	40	2.59	7.6
<i>Populus tremuloides</i>	--	--	--	28	1.27	4.7
<i>Solidago nemoralis</i>	10	0.30	0.9	26	1.26	4.5
<i>Baptisia alba</i>	--	--	--	26	0.68	3.7
<i>Quercus palustris</i>	--	--	--	18	0.87	3.0
<i>Viola sagittata</i>	18	0.14	1.5	20	0.30	2.5
<i>Gentiana saponaria</i>	--	--	--	18	0.19	2.1
<i>Rhus copallina</i>	--	--	--	10	0.78	2.1
Others*	--			--		
Totals		171.43	200.0		76.29	200.0
Average bare ground/litter		6.90			24.33	
Total species in plots	42			36		
Average species/plot	13.24			9.42		

Table 3. Frequency (%), mean cover (% of total) and importance value (I.V.) of the ground layer species encountered in the dry-mesic and the dry sand savanna, Iroquois County Conservation Area, Illinois. Also given for each site is the total number of species encountered in the plots and the average number of species per plot. *Others category Include species with IVs less than 2.0.

Species	Dry-mesic Sand Savanna			Dry Sand Savanna		
	Freq. %	Mean Cover	I.V.	Freq. %	Mean Cover	I.V.
<i>Vaccinium angustifolium</i>	72	19.72	43.7	4	0.81	1.4
<i>Pteridium aquilinum</i>	58	12.00	29.2	--	--	--
<i>Carex pensylvanica</i>	74	7.20	24.6	100	15.39	27.7
<i>Quercus velutina</i>	76	5.77	22.9	50	6.59	12.5
<i>Quercus alba</i>	50	7.59	20.9	--	--	--
<i>Rubus allegheniensis</i>	50	3.12	13.9	90	11.58	22.1
<i>Rhus copallina</i>	36	3.72	12.4	86	13.74	24.4
<i>Rubus hispidus</i>	18	1.69	5.9	2	0.06	0.3
<i>Galunssacia baccata</i>	10	1.21	3.7	--	--	--
<i>Rosa carolina</i>	16	0.43	3.6	42	1.29	5.4
<i>Euphorbia corollata</i>	18	0.14	3.5	62	2.47	8.7
<i>Lespedeza hirta</i>	8	0.67	2.4	4	0.07	0.5
<i>Schizachyrium scoparium</i>	6	0.13	1.3	56	6.67	13.2
<i>Chamaecrista nictitans</i>	2	0.01	0.4	76	1.71	9.0

<i>Sporobolus cryptandrus</i>	--	--	--	--	36	3.67	7.7
<i>Helianthemum bicknellii</i>	--	--	--	--	46	2.23	7.0
<i>Lespedeza capitata</i>	--	--	--	--	34	1.73	5.2
<i>Lithospermum croceum</i>	--	--	--	--	24	1.87	4.4
<i>Dichanthelium villosissimum</i>	--	--	--	--	32	0.75	3.8
<i>Galium pilosum</i>	--	--	--	--	26	1.06	3.7
<i>Prunus serotina</i>	2	0.30	0.9	0.9	14	2.02	3.7
<i>Koeleria macrantha</i>	--	--	--	--	22	1.33	3.6
<i>Dichanthelium oligosanthes</i>	--	--	--	--	32	0.41	3.4
<i>Rumex acetosella</i>	--	--	--	--	26	0.63	3.2
<i>Cyperus lupulinus</i>	--	--	--	--	28	0.14	2.8
<i>Potentilla simplex</i>	6	0.13	1.3	1.3	16	1.20	2.8
<i>Polygala polygama</i>	8	0.09	1.5	1.5	22	0.26	2.3
<i>Asclepias verticillata</i>	--	--	--	--	20	0.15	2.1
<i>Aureolaria pedicularia</i>	--	--	--	--	8	1.20	2.1
<i>Corylus americana</i>	--	--	--	--	4	1.31	2.0
Others*	--	0.54	7.9	7.9	--	3.31	15.0
Totals		64.46	200.0	200.0		83.65	200.0
Average bare ground/litter		41.20				14.22	
Total species in plots	28				52		
Average species/plot	5.48				10.78		

Table 4. Sorensen Index of Similarity of the ground layer vegetation of the seven communities examined, Iroquois County Conservation Area, Illinois.

	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6
Area 1 – Sedge Meadow						
Area 2 - Shrub Prairie	27.16					
Area 3 - Wet-mesic Prairie	20.00	46.80				
Area 4 - Dry-mesic Prairie	6.15	50.00	43.59			
Area 5 - Sand Flatwoods	4.55	26.87	21.05	27.45		
Area 6 - Dry-mesic Savanna	0.00	17.50	14.29	25.00	18.60	
Area 7 - Dry Savanna	0.00	11.54	10.64	11.36	8.96	30.00

APPENDIX 1: The vascular taxa encountered and collected at the Iroquois County Conservation Area are listed below by major groups. Pteridophytes (ferns and fern-allies) and Spermatophytes (seed plants), the latter divided into Monocots and Dicots. The families, genera, and species are alphabetically arranged within each group. Non-native species are indicated by an asterisk (*). After the binomial and authority, the communities where the species was observed is given (1 = marsh, 2 = sedge meadow, 3 = sand flatwoods, 4 = wet sand prairie, 5 = mesic sand prairie, 6 = dry-mesic sand prairie, 7 = dry sand prairie, 8 = shrub prairie, 9 = dry-mesic sand savanna, 10 = dry sand savanna, 11 = cultural). Following the community number(s), collecting numbers

or date collected (when collecting number not assigned) preceded by the initial of the collector's name are given (E for John E. Ebinger, Ev for Robert A. Evers, F for Mary Ann Feist, H for Fran Harty, M for Michael H. Madany, and P for Loy R. Phillippe).

PTERIDOPHYTES

ASPLENIACEAE

Asplenium platyneuron (L.) Oakes: 9; E21827

DENNSTAEDTIACEAE

Pteridium aquilinum (L.) Kuhn var. *latiusculum* (Desv.) Underw.: 7, 10; E21277

DRYOPTERIDACEAE

Dryopteris carthusiana (Villars) H.P. Fuchs: 3; P33033

Dryopteris cristata (L.) Gray: 3; P33036

EQUISETACEAE

Equisetum arvense L.: 2, 3, 4, 12; E21630

Equisetum fluviatile L.: 3, 11; E22008

Equisetum hyemale L.: 7, 9, 10; E22649

Equisetum laevigatum A. Br.: 7, 9, 10, 11; E21957

LYCOPODIACEAE

Lycopodium hickeyi Wagner, Beitel & Moran: 8; H11 October 2001; P33825

ONOCLEACEAE

Onoclea sensibilis L.: 2; E22332

OPHIOGLOSSACEAE

Botrychium dissectum Spreng.: 11; P36267

Botrychium virginianum (L.) Sw.: 3; P33038

Ophioglossum pusillum Raf.: 2, 3, 4, 5; P32965

OSMUNDACEAE

Osmunda cinnamomea L.: 3; P33276

Osmunda regalis L.: 3, 8; E21240

THELYPTERIDACEAE

Thelypteris palustris Schott: 2, 8; E22276

SPERMATOPHYTES: GYMNOSPERMS

PINACEAE

**Pinus banksiana* Lamb.: 11; P33826

SPERMATOPHYTES: ANGIOSPERMS

DICOTS

ACERACEAE

Acer negundo L.: 11; E21944

Acer saccharinum L.: 11; E21939

AMARANTHACEAE

Amaranthus albus L.: 11; Ev84994

Amaranthus tuberculatus (Moq.) J. Sauer: 11; E22633

ANACARDIACEAE

Rhus copallina L.: 6, 7, 9, 10; E21250

Rhus glabra L.: 6, 7, 9, 10, 11; E21289

Rhus hirta L.: 6, 7, 9, 10, 11; E21920

Toxicodendron radicans (L.) Kuntze: 11; P30985

Toxicodendron vernix (L.) Kuntze: 5; P33630

APIACEAE

Cicuta bulbifera L.: 2; P36259

Cicuta maculata L.: 2; E22000

**Daucus carota* L.: 11; E22296

Eryngium yuccifolium Michx.: 4, 5, 8; E22302

Osmorhiza claytonii (Michx.) C.B. Clarke: 11; E21623

Osmorhiza longistylis (Torr.) DC.: 10; P33643

Oxypolis rigidior (L.) Raf.: 8; E22587

**Pastinaca sativa* L.: 11; E21945

Sanicula canadensis L.: 11; E21932

Sium suave Walt.: 11; E22264

APOCYNACEAE

Apocynum androsaemifolium L.: 9, 10; E21968

AQUIFOLIACEAE

Ilex verticillata (L.) Gray: 3, 9; E21516

ASCLEPIADACEAE

Asclepias amplexicaulis Small: 7, 10; E21276

Asclepias hirtella (Pennell) Woodson: 8; E22326

Asclepias incarnata L.: 2, 11; E22278

Asclepias syriaca L.: 11; E22294

Asclepias tuberosa L.: 9, 10; E21270

Asclepias verticillata L.: 6, 7, 8, 9, 10, 11; E21253

ASTERACEAE

**Achillea millefolium* L.: 5, 6, 7, 8, 9, 10, 11; E21287

Ambrosia artemisiifolia L.: 11; E22404

Ambrosia trifida L.: 11; P33647

Antennaria neglecta Greene: 5, 6; P32960

Antennaria plantaginifolia (L.) Hook.: 7, 9, 10; E21588

Arnoglossum plantagineum Raf.: 2, 4, 5; E22011

**Artemisia absinthium* L.: 11; P33660

Aster dumosus L. var. *strictior* Torrey & Gray: 2, 3, 9; E22464

Aster ericoides L.: 8; sight record only

Aster lanceolatus Willd. var. *simplex* (Willd.) A.G. Jones: 3, 5, 6, 8; E22578

Aster novae-angliae L.: 2, 5, 8; E22571

Aster oolentagiensis Riddell: 7, 9, 10, 11; E21502

Aster parviceps (Burgess) Mack. & Bush: 6; E22411

Aster praealtus Poir.: 8, 11; E22632

Bidens aristosa (Michx.) Britt.: 3, 11; E22591

Bidens cernua L.: 1, 11; E22503

Bidens comosa (Gray) Wieg.: 1, 11; E22474

Bidens coronata (L.) Britt.: 4, 11; Ev85010

Bidens frondosa L.: 11; P36270

Boltonia asteroides (L.) L'Hér.: 11; E22645

**Cichorium intybus* L.: 11; E30035

**Cirsium arvense* (L.) Scop.: 11; E21947

Cirsium discolor (Muhl.) Spreng.: 11; E22407

- Cirsium muticum* Michx.: 2; E22446
Conyza canadensis (L.) Cronq.: 8, 9, 10, 11; P33617
Coreopsis palmata Nutt.: 7, 9, 10, 11; E21278
Coreopsis tripteris L.: 5, 6, 8; E22575
Doellingeria umbellata (Mill.) Nees: 2, 4; P33627
Erechtites hieracifolia (L.) Raf.: 11; E22467
Erigeron annuus (L.) Pers.: 11; E21962
Erigeron strigosus Muhl.: 6, 7, 8, 9, 10; E21257
Eupatoriadelphus maculatus (L.) R.M. King & H. Rob.: 2; E22343
Eupatorium altissimum L.: 5, 11; P33661
Eupatorium perfoliatum L.: 1, 8; E22492
Eupatorium serotinum Michx.: 1, 3; E22491
Eupatorium sessilifolium L.: 9; P33634
Euthamia graminifolia (L.) Nutt.: 2, 5, 6, 8; E21512
Euthamia gymnospermoides Greene: 11; Ev85037
Helenium autumnale L.: 4, 8; E22574
Helianthus divaricatus L.: 7, 10, 11; E22290
Helianthus giganteus L.: 2, 11; E22348
Helianthus grosseserratus Martens: 5; P33625
Helianthus mollis Lam.: 7, 8, 9, 10; E21499
Helianthus occidentalis Riddell: 7, 8, 9, 10; E22274
Helianthus strumosus L.: 8; E22583
Hieracium gronovii L.: 7, 8, 9, 10; E22325
Hieracium longipilum Torr.: 6, 11; E22284
Hieracium scabrum Michx.: 7, 9, 10; P33620
Hymenopappus scabiosaeus L'Hér.: 6, 9, 11; E21282
Ionactis linariifolius (L.) Greene: 7, 9, 10; E22514
Krigia biflora (Walt.) Blake: 2, 8; E21813
Krigia virginica (L.) Willd.: 6, 11; E21244
Lactuca canadensis L.: 5, 6, 7, 10; E22419
Lactuca floridana (L.) Gaertn.: 9; P33652
**Lactuca serriola* L.: 11; E22350
Liatris spicata (L.) Willd.: 5, 6, 8, 9, 10; E22328
**Matricaria discoidea* DC.: 11; E21953
Oligoneuron riddellii (Frank) Rydb.: 5; P33629
Parthenium integrifolium L.: 8; E21233
Pseudognaphalium obtusifolium (L.) Hilliard & Burt: 5, 7, 9, 10; E22511
Rudbeckia hirta L.: 8; E 21237, E21840

- Rudbeckia subtomentosa* Pursh: 5; P33653
Rudbeckia triloba L.: 11; P33464
Senecio pauperculus Michx.: 5; P32948
Senecio plattensis Nutt.: 11; E21633
Silphium integrifolium Michx.: 8; E22301
Solidago canadensis L.: 5, 8; sight record only
Solidago gigantea Ait.: 2, 5, 8, 11; E22428
Solidago missouriensis Ait.: 5, 8, 9; E22318
Solidago nemoralis Ait.: 5, 6, 8, 9, 10, 11; E22417
Solidago rugosa Mill.: 3, 9; P36249
Solidago speciosa Nutt.: 6, 7, 10; E22504
**Sonchus arvensis* L. var. *glabrescens* Grab. & Wimm.: 11; P33404
**Taraxacum officinale* Weber: 11; E21607
**Tragopogon dubius* Scop.: 11; E21889
Vernonia fasciculata Michx.: 2; P33667
Vernonia gigantea (Walt.) Trel.: 6, 8; E22551
Vernonia missurica Raf.: 4; P33482
Xanthium strumarium L.: 11; E22457

BALSAMINACEAE

- Impatiens capensis* Meerb.: 3, 9, 11; P33636

BETULACEAE

- Betula nigra* L.: 3, 9, 11; E21926

BORAGINACEAE

- Hackelia virginiana* (L.) I.M. Johnston: 11; P33639
Lithospermum croceum Fern.: 6, 7, 9, 10; E21268
Myosotis verna Nutt.: 11; E21871

BRASSICACEAE

- **Alliaria petiolata* (Bied.) Cavara & Grande: 11; P33044
**Arabidopsis thaliana* (L.) Heynh.: 9, 11; E21271
Arabis lyrata L.: 9, 10; P32941
**Barbarea vulgaris* R. Br.: 11; E21625
**Capsella bursa-pastoris* (L.) Medic.: 11; E21616
Cardamine bulbosa (Muhl.) BSP.: 2; E21594
Cardamine parviflora L.: 11; E21208
Cardamine pensylvanica Muhl.: 11; E21632

Draba reptans (Lam.) Fern.: 11; E21610

**Lepidium campestre* (L.) R. Br.: 11; F974

Lepidium virginicum L.: 11; E21610

Neobeckia aquatica Eaton: 1, 2; E21817

Rorippa palustris (L.) Besser var. *fernaldiana* (Butters & Abbe)

Stuckey: 2, 11; E21808

Rorippa palustris (L.) Besser var. *hispida* (Desv.) Rydb.: 6, 11;

Ev87557

**Sisymbrium altissimum* L.: 11; Ev87581

CAESALPINACEAE

Chamaecrista fasciculata (Michx.) Greene: 6, 7, 9, 10; E22269

Chamaecrista nictitans (L.) Moench: 7, 9, 10; E21495

CALLITRICHACEAE

Callitriche heterophylla Pursh: 11; E21600

Callitriche terrestris Raf.: 11; E21950

CAMPANULACEAE

Campanula aparinoides Pursh: 2; E22270

Campanulastrum americanum (L.) Small: 9; P33637

Lobelia cardinalis L.: 11; E22631

Lobelia siphilitica L.: 11; E22471

Lobelia spicata Lam.: 6, 7, 8, 9, 10; E21262

Triodanis perfoliata (L.) Nieuwl.: 11; E21877

CAPRIFOLIACEAE

**Lonicera maackii* (Rupr.) Maxim.: 11; E30036

**Lonicera morrowii* Gray: 2, 11; P32968

**Lonicera tatarica* L.: 11; E21617

Sambucus canadensis L.: 11; E21948

**Viburnum opulus* L.: 11; P33633

CARYOPHYLLACEAE

**Cerastium fontnum* Baum: 11; E21612

**Dianthus armeria* L.: 11; E21295

**Holosteum umbellatum* L.: 11; P32966

Moehringia lateriflora (L.) Fenzl: 7, 10; E21591

Paronychia canadensis (L.) Wood: 3, 9, 10; P33397

**Saponaria officinalis* L.: 11; E22295

Silene antirrhina L.: 11; E21888

**Silene pratensis* (Spreng.) Godron & Gren.: 11; E21925

Silene stellata (L.) Ait. f.: 7, 10, 11; E22285

CELASTRACEAE

Celastrus scandens L.: 10; P36271

CERATOPHYLLACEAE

Ceratophyllum demersum L.: 11; P33657

CHENOPODIACEAE

Chenopodium desiccatum A. Nels.: 7, 9, 10; E22516

Chenopodium simplex (Torr.) Raf.: 11; P33280

Cycloma atriplicifolium (Spreng.) Coult.: 11; E22406

CISTACEAE

Helianthemum bicknellii Fern.: 7, 9, 10, 11; E21507

Helianthemum canadense (L.) Michx.: 7, 9, 10; E21263

Lechea mucronata Raf.: 7, 9, 10; P33471

Lechea pulchella Raf.: 5, 6, 9; E22347

CONVOLVULACEAE

Calystegia sepium (L.) R. Br.: 11; E21940

CORNACEAE

Cornus obliqua Raf.: 2, 4; E21825

Cornus racemosa Lam.: 2, 3, 4, 8, 11; P33059

CORYLACEAE

Corylus americana Walt.: 7, 9, 10; E21285

CUSCUTACEAE

Cuscuta glomerata Choisy: 2, 4; P33670

Cuscuta gronovii Willd.: 1, 11; E22472

DROSERACEAE

Drosera intermedia Hayne: 3, 5, 8; P33405

ELAEAGNACEAE

**Elaeagnus umbellata* Thunb.: 11; E21924

ERICACEAE

Gaylussacia baccata (Wang.) K. Koch: 9; P33270

Vaccinium angustifolium Ait.: 3, 6, 8, 9; E 1586

Vaccinium corymbosum L.: 6; P33819

Vaccinium pallidum Ait.: 3, 9; E22553

EUPHORBIACEAE

Acalypha gracilens Gray: 9, 11; P33621

Acalypha rhomboidea Raf.: 11; E22462

Chamaesyce maculata (L.) Small: 11; P33665

Chamaesyce nutans (Lag.) Small: 11; P33662

Euphorbia corollata L.: 6, 7, 8, 9, 10, 11; E21231

Poinsettia dentata (Michx.) Kl. & Garcke: 11; E30039

FABACEAE

Amorpha canescens Pursh: 7, 9, 10; E21274

Baptisia alba (L.) Vent.: 6, 8, 9; E21267

Desmodium canadense (L.) DC.: 5; P33626

Desmodium obtusum (Muhl.) DC.: 7, 10; E22518

Desmodium paniculatum (L.) DC.: 7, 10; E22412

Desmodium sessilifolium (Torr.) Torr. & Gray: 7, 9, 10; E22548

Lathyrus palustris L.: 2, 6, 11; E21896

Lespedeza capitata Michx.: 6, 7, 9, 10; E21508

Lespedeza hirta (L.) Hornem.: 7, 9, 10; P33623

Lespedeza hirta (L.) Hornem. X *L. longifolia* DC.: 9; P33624

Lespedeza virginica (L.) Britt.: 9; P33699

Lupinus perennis L.: 10, 11; E21613

**Medicago lupulina* L.: 11; P33260

**Medicago sativa* L.: 11; E21860

**Melilotus albus* Medik.: 11; E30040

**Melilotus officinalis* (L.) Pallas: 11; E21874

**Robinia pseudoacacia* L.: 11; E21927

Tephrosia virginiana (L.) Pers.: 7, 9, 10, 11; E21306

**Trifolium pratense* L.: 11; E21882

**Trifolium repens* L.: 11; E21858

**Vicia villosa* Roth: 11; E30041

FAGACEAE

Quercus alba L.: 6, 9; E21264

Quercus palustris Muenchh.: 3, 6, 8; sight record only

Quercus velutina Lam.: 6, 7, 9, 10; E21307

GENTIANACEAE

Bartonia virginica (L.) BSP.: 3, 5, 6, 8, 9; P33402

Gentiana saponaria L.: 6, 8; E21510

HALORAGIDACEAE

Proserpinaca palustris L.: 3, 11; P32958

HYPERICACEAE

Hypericum adpressum Bart.: 4, 5, 8; E22321

Hypericum canadense L.: 8, 11; E21288

Hypericum gentianoides (L.) BSP.: 6, 7, 11; E22566

Hypericum mutilum L.: 8, 11; E22293

**Hypericum perforatum* L.: 11; E30038

Hypericum punctatum Lam.: 11; P36268

Hypericum sphaerocarpum Michx.: 2, 4; P33216

Triadenum fraseri (Spach) Gl.: 2; E22330

JUGLANDACEAE

Juglans nigra L.: 11; E21941

LAMIACEAE

Hedeoma hispida Pursh: 11; P33265

**Leonurus cardiaca* L.: 11; E21928

Lycopus americanus Muhl.: 1, 2, 11; E22445

Lycopus virginicus L.: 1, 2; E22331

**Mentha arvensis* L.: 1, 2; E22436

Monarda fistulosa L.: 11; E22283

Monarda punctata L.: 6, 7, 10; E21272

**Nepetea cataria* L.: 11; P33279

Physostegia virginiana (L.) Benth.: 6, 8; E22430

Prunella vulgaris L.: 11; P33644

Pycnanthemum virginianum (L.) Dur. & B.D. Jacks.: 2, 5; E22279

Scutellaria galericulata L.: 2; E22014

Scutellaria lateriflora L.: 1, 2, 3; E22494

Stachys tenuifolia Willd.: 1, 2, 8; E22323

Teucrium canadense L. var. *canadense*: 9, 10, 11; P33264

LAURACEAE

Sassafras albidum (Nutt.) Nees: 9, 10, 11; E21615

LINACEAE

Linum medium (Planch.) Britt.: 11; P33400

LYTHRACEAE

Lythrum alatum Pursh: 2, 8, 11; E21239

Rotala ramosior (L.) Koehne: 11; E22310B

MELASTOMACEAE

Rhexia virginica L.: 5, 6, 8, 11; E22319

MOLLUGINACEAE

**Mollugo verticillata* L.: 6, 11; E22418

MORACEAE

**Maclura pomifera* (Raf.) Schneider: 11; E21937

**Morus alba* L.: 11; E21943

NYCTAGINACEAE

**Mirabilis nyctaginea* (Michx.) MacM.: 11; E21876

NYSSACEAE

Nyssa sylvatica Marsh.: 3, 4; P32954

OLEACEAE

Fraxinus pennsylvanica Marsh.: 1, 2, 3; P29930

ONAGRACEAE

Circaea lutetiana L.: 3; P33277

Epilobium coloratum Biehler: 2; Ev85008

Epilobium leptophyllum Raf.: 2; E22448

Ludwigia alternifolia L.: 8, 11; E212971

Ludwigia palustris (L.) Ell.: 11; E22289

Ludwigia polycarpa Short & Peter: 11; E22481

Oenothera biennis L.: 11; E22346

Oenothera clelandii W. Dietr., Raven & W.L. Wagner: 7,9,10: E21260

Oenothera pilosella Raf.: 4, 5, 8; E21843

OXALIDACEAE

Oxalis fontana Bunge: 11; E21936

Oxalis stricta L.: 5, 11; E21868

PHRYMACEAE

Phryma leptostachya L.: 9, 10; P33638

PHYTOLACCACEAE

Phytolacca americana L.: 11; P33262

PLANTAGINACEAE

Plantago aristata Michx.: 11; P33263

**Plantago lanceolata* L.: 11; E21883

Plantago patagonica Jacq.: 7, 9, 10; E21977

Plantago rugelii Decne.: 11; E21946

POLEMONIACEAE

Phlox bifida Beck: 7, 9, 10; E21582

Phlox glaberrima L.: 2, 4, 8; E21232

POLYGALACEAE

Polygala cruciata L.: 3, 8, 11; E21518

Polygala polygama Walt.: 8, 11; E21905

Polygala sanguinea L.: 5; P30002

POLYGONACEAE

Antenoron virginianum (L.) Roberty & Vautier: 11; P33650

**Fallopia convolvulus* (L.) A. Löve: 11; E21963

Fallopia cristata (Engelm. & Gray) Holub.: 11; P33648

Persicaria amphibium (L.) S.F. Gray: 2, 4; P33705

Persicaria careyi (Olney) Greene: 3, 11; P33477

**Persicaria cespitosa* (Blume) Nakai: 11; E22286

Persicaria hydropiperoides Michx.: 1, 2, 11; E22344

Persicaria lapathifolia (L.) S.F. Gray: 2, 11; E22454

Persicaria opelousana (Riddell) Small: 2, 12; P33484

Persicaria pensylvanica (L.) Small: 11; E22639

Persicaria punctata (Ell.) Small: 2, 3; E22440

Persicaria setacea (Baldw.) Small: 1, 11; E22473

**Persicaria vulgaris* Webb & Moq.: 11; E30043

Polygonella articulata (L.) Meisn.: 7, 10; E22450

**Polygonum aviculare* L.: 11; E22305

Polygonum ramosissimum Michx.: 2; P33666

Polygonum tenue Michx.: 7, 9, 10; P33470

**Rumex acetosella* L.: 6, 7, 9, 10, 11; E21252

**Rumex crispus* L.: 11; E21866

Tracaulon sagittatum (L.) Small: 2; E22435

PORTULACACEAE

Claytonia virginica L.: 9, 10; E21583

**Portulaca oleracea* L.: 11; E22266

Talinum rugospermum Holz.: 7, 9, 10; P33406

PRIMULACEAE

Lysimachia hybrida Michx.: 2; P33479

Lysimachia lanceolata Walt.: 2, 8, 9; E22327

Lysimachia quadriflora Sims: 2, 4; P33274

Lysimachia terrestris (L.) BSP.: 4; E22006

Lysimachia thyrsiflora L.: 1, 2; E21826

RANUNCULACEAE

Anemone canadensis L.: 11; E21898

Anemone cylindrica Gray: 7, 9, 10; E21273

Anemone quinquefolia L.: 9; E21578

Caltha palustris L.: 2; E21596

Ranunculus abortivus L.: 11; E21627

Ranunculus flabellaris Raf.: 11; E21599

Ranunculus longirostris Godr.: 11; P32968.1

Ranunculus pusillus Poir.: 11; P32957

Thalictrum revolutum DC.: 8, 11; E21861

RHAMNACEAE

Ceanothus americanus L.: 7, 9, 10; E21266

**Frangula alnus* Mill.: 2; P33669

**Rhamnus cathartica* L.: 11; P33278

ROSACEAE

Agrimonia parviflora Sol.: 2, 5; E22434

Aronia melanocarpa (Michx.) Ell.: 5, 8, 9, 11; E21301

Fragaria virginiana Duchesne: 11; E21606

Geum aleppicum Jacq.: 11; E21897

Geum canadense Jacq.: 11; P33649

Geum laciniatum Murr.: 11; E21959

Malus ioensis (Wood) Britt.: 11; E21620

**Malus prunifolia* (Willd.) Borkh.: 11; P33654

Physocarpus opulifolius (L.) Maxim.: 11; E21917

Potentilla norvegica L.: 11; E30044

Potentilla simplex Michx.: 2, 5, 6, 8, 9, 10, 11; E21602

Prunus americana Marsh.: 11; E21622

Prunus serotina Ehrh.: 9, 10, 11; E21300

Prunus virginiana L.: 11; P36266

Rosa carolina L.: 7, 8, 9, 10, 11; E21275

**Rosa multiflora* Thunb.: 11; E21866

Rosa palustris Marsh.: 2, 4, 5, 8; P33217

Rubus allegheniensis Porter: 6, 9, 10, 11; E21292

Rubus flagellaris Willd.: 2, 8, 9, 10, 11; E21290

Rubus hispidus L.: 5, 6, 8, 11; E21901

Rubus occidentalis L.: 9, 10, 11; P32967

Rubus schneideri Bailey: 4, 5, 8; F990

Spiraea alba Du Roi: 2, 3, 5, 8, 11; E22268

Spiraea tomentosa L.: 5, 6, 8, 9; E21517

RUBIACEAE

Cephalanthus occidentalis L.: 1; E22337

Galium aparine L.: 11; E21624

Galium boreale L.: 1, 2, 4; Ev87573

Galium circaezans Michx.: 9, 10; P33642

Galium obtusum Bigel.: 1, 2, 4, 5, 8; E22496

Galium pilosum Ait.: 9; E21501

Galium tinctorium L.: 2; P33480

Houstonia caerulea (L.) Hook.: 11; E21603

RUTACEAE

Ptelea trifoliata L.: 11; P33220

SALICACEAE

Populus deltoides Marsh.: 2, 11; E21915

Populus grandidentata Michx.: 3, 9, 11; E21930

Populus tremuloides Michx.: 6, 8, 9, 11; E21286

Salix bebbiana Sarg.: 2; M 8 July 1977

Salix discolor Muhl.: 8; E21998

Salix humilis Marsh.: 6, 8, 9, 10, 11; E21579

Salix interior Rowlee: 2; E21824

Salix nigra Marsh.: 11; E21938

Salix petiolaris Sm.: 5; Ev87568

Salix rigida Muhl.: 11; E21609

Salix sericea Marsh.: 5, 8; E21838

SANTALACEAE

Comandra umbellata (L.) Nutt.: 6; E21581

SAXIFRAGACEAE

Heuchera americana L.: 9; E21831

Heuchera richardsonii R. Br.: 7 ; Ev87528

Penthorum sedoides L.: 1; E22333

Saxifraga pensylvanica L.: 4, 5; P32962

SCROPHULARIACEAE

Agalinis purpurea (L.) Pennell: 6, 8, 11; E22541

Agalinis tenuifolia (Vahl) Raf.: 11; E22468

Aureolaria pedicularia L.: 6, 9, 10; E22525

Gratiola neglecta Torr.: 11; E21908

Leucospora multifida (Michx.) Nutt.: 11; Ev85065

Lindernia anagallidea (Michx.) Pennell: 11; E22458

Mimulus ringens L.: 1, 11; E22335

Nuttallanthus canadensis (L.) D. Sutton: 7, 8, 9, 10; E21248

Pedicularis canadensis L.: 8; E21992

Pedicularis lanceolata Michx.: 2; E22576

Penstemon digitalis Nutt.: 11; E21865

Scrophularia lanceolata Pursh: 9, 10; E21265

**Verbascum thapsus* L.: 3, 11; E30045

**Veronica arvensis* L.: 11; E21629

Veronica peregrina L.: 11; E21628

Veronica scutellata L.: 1, 2, 4, 11; E21816

Veronicastrum virginicum (L.) Farw.: 8, 11; E22265

SOLANACEAE

Physalis heterophylla Nees: 11; E21942

Physalis virginiana Mill.: 11; E21965

Solanum carolinense L.: 11; E21933

**Solanum dulcamara* L.: 2; E21810

Solanum ptychanthum Dunal: 2, 3; P33616

ULMACEAE

Celtis occidentalis L.: 11; P33659

Ulmus americana L.: 2, 11; E22001

**Ulmus pumila* L.: 11; E30046

URTICACEAE

Boehmeria cylindrica (L.) Sw.: 1, 2, 11; E22334

Parietaria pensylvanica Muhl.: 11; E21304

Pilea pumila (L.) Gray: 9; P36269

VERBENACEAE

Phyla lanceolata (Michx.) Greene: 11; E22303

Verbena bracteata Lag. & Rodr.: 11; E21302

Verbena hastata L.: 2, 8; E22282

Verbena urticifolia L.: 11; P33646

VIOLACEAE

Viola lanceolata L.: 5, 6, 8; E21593

Viola pedata L.: 7, 9, 10; E21585

Viola pratensis Greene: 9, 11; E21589

Viola primulifolia L.: 3, 5, 6, 8, 11; E21988

Viola sagittata Ait.: 5, 6, 7, 8, 9, 10; E21580

Viola sororia Willd.: 8, 9, 10; E21592

VITACEAE

Parthenocissus quinquefolia (L.) Planch.: 11; E21934

Vitis riparia Michx.: 3, 9, 10; P33701

MONOCOTS

ACORACEAE

Acorus americanus (Raf.) Raf.: 4, 11; P33062

ALISMATACEAE

Alisma subcordatum Raf.: 1; E22340

Sagittaria latifolia Willd.: 11; P33655

AMARYLLIDACEAE

Hypoxis hirsuta (L.) Coville: 6, 7; Ev87576

COMMELINACEAE

Commelina erecta L.: 6, 7, 10, 11; E21243

Tradescantia ohimensis Raf.: 6, 7, 9, 10, 11; E21256

CYPERACEAE

Bulbostylis capillaris (L.) C.B. Clarke: 6; P33821

Carex bebbii Olney: 6; E21261

Carex blanda Dewey: 9, 10; P32956

Carex brachyglossa Mack.: 5; F981

Carex brevior (Dewey) Mack.: 5, 11; E21912

Carex buxbaumii Wahlenb.: 2, 3, 4; E21597

Carex cephalophora Muhl.: 3, 9, 10; P33051

Carex crawei Dewey: 5, 11; E21881

Carex cumulata (L.H. Bailey) Fern.: 3; P36256

Carex emmonsii Dewey: 3, 5; P32943

Carex festucacea Schk.: 3; P33053

Carex foenea Willd.: 9; E21590

Carex haydenii Dewey: 2, 3, 4, 5; P32946

Carex interior L.H. Bailey: 4, 5; P32951

Carex lupuliformis Sartw.: 2; E22341

Carex molesta Mack.: 4; P33055

Carex muhlenbergii Schk.: 7, 10, 11; E21255

Carex normalis Mack.: 5; F975

Carex pellita Willd.: 2; E21595

Carex pensylvanica Lam.: 7, 9, 10; E21584

Carex physorhyncha Liebm.: 7, 8, 9, 10, 11; E21851

- Carex sartwellii* Dewey: 2; P32961
Carex scoparia Schk.: 2, 11; E21822
Carex stricta Lam.: 2; E21598
Carex suberecta (Olney) Britt.: 2, 3, 4, 5, 9; P32955
Carex swanii (Fern.) Mack.: 6, 9; E21247
Carex umbellata Schk.: 5, 6; P32963
Carex vesicaria L.: 4; P33063
Carex vulpinoidea Michx.: 11; E21880
Cyperus bipartitus Torr.: 11; E22643
Cyperus erythrorhizos Muhl.: 11; E22478
Cyperus lupulinus (Spreng.) Marcks: 6, 7, 10; E21246
Cyperus schweinitzii Torr.: 6, 7, 10; E21242
Cyperus squarrosus L.: 11; E22636
Cyperus strigosus L.: 11; E22461
Eleocharis acicularis (L.) Roem. & Schultes: 12; E22637
Eleocharis erythropoda Steud.: 1, 2; E21822
Eleocharis ovata (Roth) Roem.: 11; E21298
Eleocharis verrucosa (Svenson) Harms: 1, 2, 4, 5, 8, 12; E21895
Eleocharis wolfii Gray: 2, 3, 4; P33048
Fimbristylis autumnalis (L.) Roem. & Schultes: 11; E22455
Fimbristylis puberula (Michx.) Vahl: 11; Ev87587
Hemicarpha micranthus (Vahl) Pax: 11; E22309
Rhynchospora capitellata (Michx.) Vahl: 3, 5, 8, 11; E21291
Schoenoplectus acutus (Muhl.) A. Löve & D. Löve: 1; E21972
Scirpus cyperinus (L.) Kunth: 2, 4, 11; P33615
Scirpus pendulus Muhl.: 11; E21885
Scleria pauciflora Muhl. var. *caroliniana* (Willd.) Wood: 6, 9; P33403
Scleria triglomerata Michx.: 5, 6, 8, 10; P33401

HYDROCHARITACEAE

- Elodea canadensis* L.C. Rich.: 11; E30047

IRIDACEAE

- Iris shrevei* Small: 2, 5; E21807
Sisyrinchium albidum Raf.: 6, 11; E21576
Sisyrinchium atlanticum Bickn.: 5, 8; E21986

JUNCACEAE

- Juncus acuminatus* Michx.: 2, 11; E21296
Juncus brachycarpus Engelm.: 11; Ev85014
Juncus bufonius L.: 11; F973.2
Juncus canadensis J. Gay: 1, 8; E22487
Juncus dudleyi Wieg.: 2, 5, 6; E21806
Juncus greenii Oakes & Tuckerm.: 6; E21235
Juncus marginatus Rostk.: 8; E21993
Juncus nodosus L.: 11; Ev81372
Juncus tenuis Willd.: 9, 10, 11; E21952

LEMNACEAE

- Lemna minor* L.: 11; E30048
Spirodela polyrrhiza (L.) Schleiden: 11; E22291

LILIACEAE

- Alettris farinosa* L.: 4, 5, 6, 8, 9; E21234
**Asparagus officinalis* L.: 11; E21949
Maianthemum canadense Desf.: 3; P33488
Polygonatum commutatum (Schult.) A. Dietr.: 9, 10; E21284
Smilacina racemosa (L.) Desf.: 9, 10; E21305
Smilacina stellata (L.) Desf.: 9, 10; E21280

ORCHIDACEAE

- Liparis liliifolia* (L.) Rich.: 3; P33034
Liparis loeselii (L.) Rich.: 3; F985
Platanthera flava (L.) Lindl. var. *herbiola* (R. Br.) Luer: 4; P33049
Platanthera lacera (Michx.) G. Don: 8; E21982
Spiranthes cernua (L.) Rich.: 5, 8; E22648

POACEAE

- **Agrostis gigantea* Roth: 5, 11; E21236
Agrostis hyemalis (Walt.) BSP.: 3, 4, 5, 8, 11; E21902
Agrostis scabra Willd.: 3, 4, 6, 7, 9, 10; E22413
Alopecurus carolinianus Walt.: 11; E21894
Andropogon gerardii Vitman: 5, 6, 7, 8, 9, 10; E22556
Andropogon virginicus L.: 8; P36273
Aristida basiramea Engelm.: 7, 10; E22415
Aristida purpurascens Poir.: 7, 10; E21503

- Aristida tuberculosa* Nutt.: 7, 10; E22416
Bouteloua curtipendula (Michx.) Torr.: 11; E22506
**Bromus commutatus* Schrad.: 11; E21872
**Bromus inermis* Leyss.: 10, 11; E21862
**Bromus japonicus* Thunb.: 11; Ev102859
Bromus latiglumis (Shear) Hitchc.: 11; P33467
**Bromus tectorum* L.: 11; E21621
Calamagrostis canadensis (Michx.) P. Beauv.: 2, 8; E21811
Cenchrus longispinus (Hack.) Fern.: 11; E22297
**Dactylis glomerata* L.: 11; E21618
Danthonia spicata (L.) Roem. & Schultes: 9, 10; F989
Dichanthelium lindheimeri (Nash) Gould: 3, 6, 7, 10, 11; E21259
Dichanthelium meridionale (Ashe) Freckm.: 11; E21954
Dichanthelium oligosanthes (Schult.) Gould: 7, 9, 10, 11; E21258
Dichanthelium perlongum (Nash) Freckm.: 7, 9, 10; E21853
Dichanthelium villosissimum (Nash) Freckm.: 7, 9, 10, 11; E21249
Digitaria filiformis (L.) Koel.: 9, 11; P33697
**Digitaria ischaemum* (Schreb.) Schreb.: 11; E22299
**Digitaria sanguinalis* (L.) Scop.: 11; E22300
**Echinochloa crus-galli* (L.) P. Beauv.: 2, 11; E21497
Elymus canadensis L.: 11; P33656
Elymus virginicus L.: 11; E22262
**Elytrigia repens* (L.) Desv.: 11; E21869
**Eragrostis cilianensis* (All.) Vign.: 11; E22534
Eragrostis hypnoides (Lam.) BSP.: 11; E22480
Eragrostis pectinacea (Michx.) Nees: 11; E22308
Eragrostis spectabilis (Pursh) Steud.: 7, 9, 10; E22510
Glyceria septentrionalis Hitchc.: 1; E21974
Glyceria striata (Lam.) Hitchc.: 2; E22003
Heterostipa spartea (Trin.) Barkworth: 7, 9, 10; E21281
Hierochloë odorata (L.) P. Beauv.: 5; F988
**Hordeum jubatum* L.: 11; E21884
Koeleria macrantha (Ledeb.) Spreng.: 7, 9, 10, 11; E21269
Leersia oryzoides (L.) Swartz: 2, 11; E22641
Leersia virginica Willd.: 3, 9; P33651
Leptoloma cognatum (Schult.) Chase: 7, 10; E21245
Muhlenbergia mexicana (L.) Trin.: 2, 3, 5, 9; P33476
Muhlenbergia schreberi J.F. Gmel.: 11; P33640
Panicum capillare L.: 11; Ev85024

- Panicum dichotomiflorum* Michx.: 11; E22564
Panicum rigidulum Bosc: 3, 8, 9, 10; E21496
Panicum virgatum L.: 5, 6, 8, 9, 10, 11; E22550
Paspalum bushii Nash: 7, 10; E 21511, E22260
Paspalum laeve Michx.: 11; P33645
**Phalaris arundinacea* L.: 2, 3; E21814
**Phleum pratense* L.: 11; E21299
**Poa compressa* L.: 9, 10, 11; E21923
**Poa pratensis* L.: 2, 5, 6, 7, 8, 9, 10, 11; E21604
Schizachyrium scoparium (Michx.) Nash: 5, 6, 7, 8, 9, 10; E21506
**Setaria faberi* R.A.W. Herrm.: 11; E22298
**Setaria viridis* (L.) P. Beauv.: 11; E30034
Sorghastrum nutans (L.) Nash: 5, 6, 8; E22561
Spartina pectinata Link: 1, 3, 5, 8; E22342
Sphenopholis obtusata (Michx.) Scribn.: 2, 11; E21879
Sporobolus clandestinus (Biehler) Hitchc.: 7, 9, 10; E21500
Sporobolus cryptandrus (Torr.) Gray: 11; E22405
Tridens flavus (L.) Hitchc.: 6, 7, 9, 10, 11; E22546
Triplasis purpurea (Walt.) Chapm.: 7, 9, 10; E22409
Vulpia octoflora (Walt.) Rydb.: 7, 9, 10; E21855

POTAMOGETONACEAE

- **Potamogeton crispus* L.: 1; P30046
Potamogeton foliosus Raf.: 11; P33663
Potamogeton nodosus Poir.: 11; P33658

SMILACACEAE

- Smilax lasioneuron* Hook.: 11; E21873

SPARGANIACEAE

- Sparganium eurycarpum* Engelm.: 1; E21970

TYPHACEAE

- Typha latifolia* L.: 1, 2, 11; P33486

XYRIDACEAE

- Xyris torta* Sm.: 8, 11; E22315

A NEW NAME FOR *AGERATINA POCHUTLANA* B.L.TURNER

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Phytologia 91(3): 439 (December, 2009).

The recently described *Ageratina pochutlana* B.L. Turner (Phytologia 90: 359. 2008) is illegitimate because of the earlier *A. pochutlana* B.L. Turner (2006). This is a lapse, no doubt occasioned by my aging forgetfulness. The two taxa are both from the Distrito Pochutla, but belong to different subgenera of *Ageratina*: the earlier to subgenus *Neogreenella*, the latter to subgenus *Ageratina*.

The following is proposed for the superfluous name:

***Ageratina lapsensis* B.L. Turner, nom. nov.**

Based upon *Ageratina pochutlana* B.L. Turner, Phytologia 90: 359. 2008.

Not *Ageratina pochutlana* B.L. Turner, Lundellia 9: 3. 2006.

It should be noted that the day of collection on the type specimen of *A. lapsensis* should be 11 Mar instead of 3 Nov (a misrepresentation of 3/11 in my original reading).

RECENSION OF THE MEXICAN SPECIES OF SECTION *ULIGINOSAE* OF *SALVIA* (LAMIACEAE)

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ABSTRACT

Salvia sect. *Uliginosae* of Mexico is treated as having 28 species, five of these described as new: ***Salvia chazaroana*** B.L. Turner, **sp. nov.**, from Veracruz; ***Salvia galloana*** B.L. Turner, **sp. nov.**, from Guerrero; ***Salvia novoleontis*** B.L. Turner, **sp. nov.**, from Nuevo Leon; ***Salvia textitlana*** B.L. Turner, **sp. nov.**, from Oaxaca; and ***Salvia paulwalleri*** B.L. Turner, **sp. nov.**, from Durango. Photographs of the holotypes are provided, along with a simplified key to the 28 species, and maps showing their distributions. *Phytologia* 91(3): 440-466 (December, 2009).

KEY WORDS: *Salvia*, Lamiaceae, Mexico, sect. *Uliginosae*

13. SECT. *ULIGINOSAE*

Perennial rhizomatous or stoloniferous herbs to 1 m high, rarely shrubs or subshrubs 1-3 m high. Leaves highly variable, linear to lanceolate to oblanceolate, ovate to deltate, or rarely cordate, markedly petiolate to sessile. Capitulescence a terminal, elongate, spike, the floral bracts soon deciduous. Calyces relatively small, the upper lip 5-7 veined. Corollas mostly blue, blue-black or rarely white, the tubes relatively short. Gubernaculum more or less deltoid, dentate. Styler shafts pilose apically, the upper branches linear, 2-3 times as long as the lower, deltoid, branches.

TYPE: *Salvia uliginosa* Benth., of South America

As well-noted by Epling (1939), a very large highly variable section, largely recognized by its relatively small, blue or white,

flowers having 5-7 veined upper calyces, gubernacula deltoid, and styler branches pilose.

KEY TO SPECIES

1. Plants widespread in Mexico, not in Chi, Coa.....(3)
1. Plants of Chi and Coa.....(2)
2. Plants mostly 30-50 cm high, arising from thick rhizomes.....
.....**S. arizonica**
2. Plants mostly 10-30 cm high, arising from slender rhizomes.....
.....**S. forreri**
3. Plants with leaves all basal or essentially so, their blades mostly
3-6 cm wide; stems arising from a tuberous root.....**S. nana**
3. Plants not as described in the above.....(4)
4. Blades of mid-stem leaves lanceolate, ovate, to deltoid or subcordate,
mostly 2-5 times as long as wide.....(7a)
4. Blades of mid-stem leaves linear, mostly 6-12 times as long as wide
.....(5)
5. Plants eglandular along the rachis, mostly 20-30 cm high...**S. laevis**
5. Plants glandular-pubescent along the rachis, mostly 10-40 cm high..
.....(6)
6. Blades not reticulate-veined beneath, having but a single prominent
mid-rib; northeastern Mexico.....**S. unicostata**
6. Blades paripinnate or reticulate-veined beneath; Nay, Jal....**S. firma**
- 7a. Plants not as described below.....(8)
- 7a. Plants mostly 10-30 cm high, the stems with slender rhizomes
and/or stolons rooting at the nodes; leaf blades mostly 10-30 mm
long; Nue, Tam, San, Ver.....(7b)
- 7b. Plants mostly 10-20 cm high, the stems sprawling, arising from
slender rhizomes; Sierra Magdalena, Ver.....**S. chazarroana**
- 7b. Plants mostly 20-30 cm high, the stems erect, arising from tap roots
or woody corms; Nue, Tam, San.....(7c)

- 7c. Leaf blades ovate-lanceolate, 2-3 times as long as wide;
corollas 10-15 mm long.....**S. novoleontis**
- 7c. Leaf blades subdeltoid, 1-2 times as long as wide;
corollas 15-20 mm long.....**S. villosa**
8. Leaves cordate-apiculate; corollas blue, the tubes 11-15 mm long;
Gue.....**S. hamulus**
8. Leaves and flowers not as described in the above.....(9)
9. Flowers white; leaves widest near the middle; petioles 1-6 mm long;
Mic.....**S. assurgens**
9. Plants not as described in the above.....(10)
10. Stems prostrate; leaves 1.0-2.5 cm long; petioles 1-2 mm long;
Hid.....**S. lozani**
10. Plants not as described in the above.....(11)
11. Blades of leaves mostly over 3 cm long.....(17)
11. Blades of leaves mostly 1-3 cm long.....(12)
12. Calyces ca 10 mm long; Gue**S. galloana**
12. Calyces 4-7 mm long; Dur, Jal, Oax.....(13)
13. Leaves decidedly deltoid, thickened, the margins glandular-
pubescent; San.....**S. villosa**
13. Plants not as described in the above.....(14)
14. Calyx 6-7 mm long; stems pubescent with shorter, softer, hairs 0.2-
1.0 mm long or less.....(16)
14. Calyx 4-5 mm long; stems pubescent with stiffly-spreading
glandular hairs 1-2 mm long.....(15)
15. Blades of leaf more nearly ovate, the margins ciliate with hairs
ca 2 mm long; Jal.....**S. veronicifolia**
15. Blades of leaf more nearly deltoid, the margins w/o elongate cilia;
Dur.....**S. paulwalleri**

16. Petioles 1-4 mm long; Jal.....**S. manantlanensis**
 16. Petioles 10 mm long, or longer; Oax.....**S. tricuspidata**
- 17(11). Blades of leaves more nearly ovate or lanceolate.....(22)
 17. Blades of leaves more nearly deltoid.....(18)
18. Calyces and stems glandular-pubescent; leaves thickened; San.....
**S. villosa**
 18. Plants not as described in the above.....(19)
19. Calyces and/or floral bracts to some extent setulose with stiff
 spreading hairs; Mic, Mex, Mor, Gue?, Oax.....**S. setulosa**
 19. Plants not as described in the above.....(20)
20. Corolla tubes 3-5 mm long; calyces glandular-pubescent; Oax.....
**S. pusilla**
 20. Corolla tubes 6-8 mm long; calyces not glandular-pubescent.....(21)
21. Corollas lavender, ca 1.5 cm long.....**S. oreopola**
 21. Corollas blue, ca 2 cm long.....**S. glechomifolia**
22. Calyx and rachis densely pubescent with white, glandular or
 eglandular, hairs 1.0-1.5 mm long; Mic.....**S. assurgens**
 22. Plants not as described in the above.....(23)
23. Leaves sessile or nearly so; Gue.....**S. eplingiana**
 23. Leaves decidedly petiolate.....(24)
24. Leaves markedly reticulate-venose and densely white-tomentose
 beneath; Mic.....**S. indigocephala**
 24. Leaves not as described in the above.....(25)
25. Blades of leaf deltoid, about as long as wide; petioles 1-3 mm long;
 Sin.....**S. paulwalleri**
 25. Plants not as described in the above.....(26)

- 26. Shrubs 1-3 m high; corollas blue-black; leaves lustrous, glabrous and markedly glandular-punctate beneath; Gue.....**S. hintonii**
- 26. Plants not as described in the above.....(27)
- 27. Blades of leaves lanceolate to oblanceolate, widest near the middle; rachis glandular-pubescent, rarely not; Sin, Dur, Nay, Jal.....**S. sinaloensis**
- 27. Blades ovate, widest near the base.....(28)
- 28. Plants in Nay, Jal.....(30)
- 28. Plants not in Nay, Jal.....(29)
- 29. Plants not in Oax.....**S. forreri**
- 29. Plants in s Oax.....**S. textitlana**
- 30. Rachis of spike glandular-pubescent; calyx 5-6 mm long; Jal.....**S. rostellata**
- 30. Rachis of spike eglandular; calyx 8-9 mm long; Nay, Jal.....**S. firma**

SALVIA ARIZONICA A. Gray, Syn. Fl. N. Amer. 2: 370. 1886.

Map 1.

Salvia arizonica var. *huachucana* M.E. Jones

s Chi, n Coa, and sw U.S.A., montane habitats in oak- conifer forests of the Chihuahuan Desert , 2000-2600 m; flowering: Aug-Oct.

Closely related to *S. forreri* and distinguished from that species largely by habit, as noted by Epling (1939). So far as known, the two taxa do not grow together or intergrade, unless one accepts the isolated populations of *S. arizonica* from southern Coa and Chi, referred to by Epling. I treat the latter as part of the *S. forreri* complex, largely on the basis of geography. Were the two taxa to be combined, the earliest name, by two years, is that of *S. arizonica*.

SALVIA ASSURGENS Kunth, Nov. Gen. Sp. Pl. 2: 293. 1817. **Map 2.**

Mic, oak or pine-oak forests, 2000-2200 m; flowering: Jun-Aug.

Perennial herbs with decumbent or sprawling stems; leaves highly variable as to size but the blades usually widest near the middle with very short petioles; flowers arranged in strict or interrupted spikes, the corollas white.

This is a relatively common species in central Mic, to judge from assembled collections (LL-TEX). Because of the variation in leaf size, it is keyed in two places in the above key. Epling (1939) notes that "Save for the more lax inflorescence there is apparently little to suggest segregation of *S. sinaloensis*;" he goes on to note that *S. prunifolia* is scarcely separable from *S. assurgens*, the former largely separated by its longer petioles. *Salvia assurgens* is readily distinguished from *S. sinaloensis* by its white flowers, but I treat *S. prunifolia* as synonymous with *S. sinaloensis*.

SALVIA CHAZAROANA B.L. Turner, *sp. nov.* **Fig 1, Map 3.**

Salviae forreri Greene similis sed differt plantis minoribus, caulibus decumbentibus vel prostratis ad nodos radicanibus, foliis minoribus, petiolis brevioribus (3-6 mm vs. 8-25 mm), et calycibus glandulosi-pubescentibus.

Prostrate perennial herbs to 20 cm high, abundantly rooting at the nodes. **Leaves** glabrous beneath or nearly so, mostly 1.0-2.5 cm long, 0.7-1.1 mm wide; petioles 3-6 mm long; blades broadly ovate to subdeltoid, upper surfaces minutely spotted with an array of flattened, branched, white trichomes, the lower surfaces markedly glandular-punctate throughout, the margins crenate. **Spikes** terminal, ca 4 cm long, the flowers arranged ca 4 to a node, the axis pubescent with spreading glandular-trichomes ca 0.6 mm high. **Floral bracts** ovate, 5-6 mm long, 2.5-3.5 mm wide, soon deciduous. **Pedicels** 1-2 mm long. **Calyces** 5-7 mm long, the upper lip 7-nerved, trifid at the apex, the lower lobes apiculate, ca 2.5 mm long; tubes 3.5-4.0 mm long, hispid below, the upper margins glandular-pubescent. **Corollas** ca 10 mm long, papillose in lines within, but mostly smooth, "blue with a white stripe in the lower lip;" tubes ca 7 mm long; upper lip ca 4 mm long; lower lip ca 7 mm long. **Anthers** blue, nestled within the upper lip, the gubernaculum narrowly deltoid. **Styles** flattened apically, densely

pilose dorsally, the lower stigmatic branches ca 0.8 mm long, the upper branches 3 times as long or more. **Nutlets** (immature) glabrous.

TYPE: MEXICO. VERACRUZ: Mpio. Tonayan, Sierra de la Magdalena, "unpaved road from Tonayan to Monte Real, and then a trail to Cerro de la Magdalena," pine-oak cloud forests, 1600-2500 m, 20 Dec 1989, *M. Chazaro B. et al.* 6050 (holotype WISC!; isotypes TEX!).

ADDITIONAL COLLECTIONS: MEXICO. VERACRUZ: Mpio. Coactzintla, Cerro de la Magdalena, 19 43 43 N, 95 59 00 W, 2600-2650 m, 1 Nov 2008, *P. Carillo-Reyes et al* 5444 (IBUG). [not examined; info from collectors]. **Mpio. Tlacolulan**, "cerca de la Cima del Cerro de la Magdalena, subiendo por el Epazote," 2500 m, 22 Jul 1984, *M. Chazaro B.* 3121 (MEXU).

Because of its low prostrate habit and small foliage, this taxon is readily recognized.

According to Flores (1938), the Cerro de la Magdalena is formed from an isolated volcano at the junction of the Sierra Madre Oriental and the Trans-Mexican volcanic belt. The summit (ca 2700 m) is exposed to strong winds, with frequent rains and mists. The vegetation consists of montane grasslands (mainly *Muhlenbergii* spp.) and pine-oak forests.

Ramamoorthy (by annotation) independently found this taxon to be new, proposing the name *S. margueritiana*. The latter name was also proposed by Ramamoorthy for several other taxa of *Salvia*, one of which I had already taken up (in prep.) when a photograph of the MEXU sheet (cited above) was examined.

It is a pleasure to name this remarkable herb for my equally remarkable colleague, Miguel Chazaro B., indefatigable collector and spirited systematist of the old school: he walks wayward trails to gather his botanical booty (unlike the more modern workers who tend to gather their plants along paved highways).

SALVIA EPLINGIANA Alziar, Biocosme Mesogéen 5: 86. 1988. **Map 8.**

Salvia tricuspis Epling (1940), not *Salvia tricuspis* Franchet (1891)

Gue, Distr. Mina, pine-oak forests, 1700-2100 m; flowering: Nov-Mar.

Perennial herbs 1-2 m high, readily recognized by its relatively large, lanceolate, tapering, nearly sessile leaves and glandular calyces. Alziar also notes that it "May be distinguished from *S. rostellata* [of Jal] by the glandular inflorescence."

SALVIA FIRMA Fernald, Proc. Amer. Acad. Arts 35: 502. 1900. **Map 8.**

Nay and Jal, oak forests on volcanic slopes, ca 1200 m; flowering: Sep-Oct.

Perennial herbs 20-40 cm high, the lower stems glabrous to eglandular, the upper stems and rachis glandular-pubescent (rarely not); leaves linear-lanceolate to linear-ob lanceolate; spikes 20-30 cm long, much interrupted; corollas blue, ca 1.5 cm. long.

A poorly collected taxon but readily recognized by its rather reticulate, glabrous, mostly lanceolate to oblanceolate, nearly sessile, leaves.

SALVIA FORRERI Greene, Pittonia 1: 156. 1888. **Map 1.**

Salvia parrasana Brandegees

s Chi, s Coa, s Nue, s Tam, Sin, Dur, Zac, San, Que? and Hid, pine-oak forests, 1800-3000 m; flowering: Jul-Aug.

A relatively common, widespread, very variable, taxon, closely related to *S. arizonica* and perhaps not sufficiently distinct to warrant specific status, as noted under the latter.

SALVIA GALLOANA B.L. Turner, sp. nov. Fig 2, Map 4.

Salviae hintonii Epling similis sed foliis minoribus subter reticulati-venosis (vs. non reticulato-venosis), corollis caeruleis (vs. caesio-nigribus), et calycibus 4-7 mm longis (vs. ca. 10 mm).

Suffrutescent perennial herbs to 1.5 m high. **Mid-stems** pubescent with arcuate, up-turned, hairs. **Leaves** mostly 2-3 cm long, 1.0-1.5 cm wide; petioles 2-5 mm long; blades ovate, markedly reticulate-venose with surfaces glandular-punctate, their margins serrulate. **Flowers** arranged in terminal interrupted spikes 6-12 cm long; peduncles 3-5 cm long; rachis glandular-pubescent, the floral bracts (if any) deciduous. **Calyces** (flowering) ca 10 mm long, glandular-pubescent, the upper lip with 5-7 ribs, the lower lip bifid, somewhat longer than the upper. **Corollas** blue, ca 2.5 cm long, the tube ca 2 cm long, the upper lip 5-6 mm long, somewhat shorter than the lower. **Stamens** 2, inserted at the throat; anthers purple, ca 2 mm long. **Styles** pilose above, the upper branches ca 3 times longer than lower. **Nutlets** ovoid, pale tan, ca 2.5 mm long, 2 mm across.

TYPE: MEXICO. GUERRERO: Mpio. Chichihualco, "32 km al NE de Puerto del Gallo, camino Atoyac-Filo de Caballo," pine forests, ca 2580 m, 23 Nov 1983, E. Martínez S. & F. Barrie 5678 (Holotype: TEX).

The species is named, in part, for Puerto del Gallo, from which a road takes one to the type locality.

SALVIA GLECHOMIFOLIA Kunth, Nov. Gen. Sp. Pl. 2: 290. 1817. Map 3.

Salvia lentiginosa Brandege

Salvia reticulata Mart. & Gal.

San, Gua, Mic, Mex, Pue and Oax, pine-oak forests, 2000-3200 m; flowering: May-Oct.

Perennial, rhizomatous, herbs to 40 cm high.

This is a widespread highly variable species, especially in leaf shape.

SALVIA HAMULUS Epling, Repert. Spec. Nov. Regni Veg. Beih. 110: 72. 1938. **Map 2.**

Gue (Distr. Mina), pine and fir forests, 1500-2500 m; flowering: Sep-Nov.

Perennial rhizomatous herbs to 40 cm high, readily distinguished from related taxa by its cordate leaves.

SALVIA HINTONII Epling, Repert. Spec. Nov. Regni Veg. Beih. 110: 73. 1938. **Map 9,**

Gue, pine-oak forests, 1700-2500 m; flowering: Oct-Mar.

Shrub 1.5-3.0 m high; leaves 3-8 cm long, glabrous beneath or nearly so, and described as having "blue-black" corollas.

SALVIA INDIGOCEPHALA Ramamoorthy, Taxon 32: 466. 1983. **Map 1.**

Salvia cyanicephala Epling (1940), not *Salvia cyanocephala* Epling (1936, from Colombia)

Mic, vicinity of Coalcoman, oak woodlands, 2400 m; flowering: Dec.

Perennial herbs to 1 m high; because of the distinctive leaves, a readily identified taxon.

In his original description, Epling notes "Very similar to *S. setulosa* with which it may prove to be conspecific." He goes on, however, to call to the fore several seemingly valid characters that serve to distinguish between them.

SALVIA LAEVIS Benth., Lab. Gen. Sp. 251. 1833. **Map 5.**

Salvia comosa var. *hypoglauca* (Briq.) Fernald

Salvia hypoglauca Briq.

Salvia pseudocomosa Epling

Tam, San, Que, Mic, Mex, Tla, Ver and Pue, pine-oak forests, 2000-2500 m; flowering: Jun-Aug.

Closely related to *S. unicostata* but readily distinguished by the characters brought to the fore in the above key.

Epling (1939) distinguished his *S. pseudocomosa* from *S. laevis* largely by leaf pubescence: pubescent in the former, glabrous in the later. He commented further his novelty "Suggests strongly a hybrid between *S. prunelloides* or *S. glechomifolia* and *S. laevis*," which it well might be. Passes imperceptibly into *S. laevis* and *S. prunelloides*.

SALVIA LOZANI Fernald, Proc. Amer. Acad. Arts 43: 64. 1907. **Map 2.**

Hid, known only from pine forests in the vicinity of Trinidad, ca 2000 m; flowering: Jul-Aug.

Because of its small, nearly sessile, leaves and prostrate stems which root at the nodes, an easily identified species, not likely to be confused with another.

SALVIA MANANTLANENSIS Ramamoorthy, Bull. Mus. Nation. Hist. Nat., B, Adansonia, Ser. 4, 9: 173. 1987. **Map 7.**

Jal, pine-oak forests, Sierra de Manantlan, 2200-2400 m; flowering: Dec-Jan.

Sprawling perennial herbs 30-40 cm high, readily rooting at the lower nodes; blades of leaves ovate, mostly 2-4 cm long, the petioles 2-7 mm long; calyces 6-7 mm long, pubescent with glandular hairs; corolla blue or rarely white, ca 1.6 mm long, the tube ca 8 mm long.

SALVIA NANA Kunth, Nov. Gen. Sp. Pl. 2: 289. 1817. **Map 4.**
Salvia prunelloides Benth., not *S. prunelloides* Kunth

Dur, Zac, San, Gua, Oax and Guatemala, pine and pine-oak forests, 1800-3500 m; flowering: Jun Oct.

Because of its broad, mostly basal leaves, an easily identified species.

SALVIA NOVOLEONTIS B.L. Turner, *sp. nov.* Fig. 3, Map 6.

Salvia villosae Fernald similis sed differt plantis minoribus, laminis foliorum plerumque ovati-lanceolatis 2-3plo longioribus quam latoribus (vs. subdeltoideis, 1-2plo longioribus quam latoribus), et corollis minoribus (10-15 mm longis vs. 15-20 mm).

Perennial herbs 20-40 cm high, the stems arising from lignescent tap roots or woody corms 2-3 cm long. **Stems** moderately pubescent with erect, glandular trichomes 0.5-1.0 mm high. **Leaves** mostly 1.5-3.0 cm long; petioles 2-6 mm long; blades mostly ovate, 2-3 times as long as wide, pubescent above and below with mostly glandular hairs, especially along the margins. **Inflorescence** a terminal interrupted spike 10-30 cm long; peduncles 5-10 cm long; bracts small, ovate, 3-4 mm long, soon deciduous. **Flowers** mostly 2 to a node, the pedicels 1-4 mm long. **Calyces** (flowering) 5-6 mm long, glandular-pubescent, the two lips ca equal in length, the upper lip with 5-7 well-defined ribs. **Corollas** blue, 10-15 mm long; tubes 5-6 mm long, the lower lip ca 6 mm long, twice as long as the upper. **Stamens** attached at the throat, the anthers white, ca 2 mm long, not exerted. **Styles** (upper portion) densely pilose, the upper style branches purplish, 2-3 mm long, sigmoid or twisted, the lower branches arcuate, ca 1/3 as long as upper. **Nutlets** ovoid, smooth, tan to dark brown, ca 2 mm long, 1.5 mm wide.

TYPE: MEXICO. NUEVO LEON: Mpio. Zaragoza, 11 km al E de San Antonio Pena Nevada, "Bosque de Pinoneros con Juniperus, Pinus, Rhus y Arctostaphylos." 2000-2500 m, 23 50 N, 99 58 W, 24 May 1992, *L. Hernandez S. 2681* [with M. Martinez y J. Jimenez] (Holotype: TEX).

ADDITIONAL COLLECTIONS EXAMINED: MEXICO. NUEVO LEON: Mpio. Aramberri, "La Escondida-Zamora. 1795 m, 23 Jul 1993, *Hinton et al. 22994* (TEX); **Mpio. Doctor Arroyo**, ca 30 km ENE Doctor Arroyo, "W base of Cerro Pena Nevada, large area of gypsum outcrops, 6600 ft, " on exposed gypsum (only on gyp)" 3-5 Aug 1981, *Nesom 4274* (TEX); road between Matahuela and Doctor Arroyo, 17 Jun 1992, *Villarreal s.n.* (TEX). **SAN LUIS POTOSI: Mpio Charcas**, 6 km al de Miguel Hidalgo, 7 Jul 1985, *Tenorio L. 9203* (TEX).

Salvia novoleontis presumably occurs only in gyp soils, this documented by *Nesom 4274* (cited above). The closely related, *S. villosa*, is known to me only from two areas in San Luis Potosi, the type itself (a Schaffer collection from Minas de San Rafael, San Miguelito) and seven sheets (TEX) from the vicinity of Guadalcázar where it is said to occur in limestone soils (*Barrie 379* and *Simpson 7032*).

SALVIA OREOPOLA Fernald, Proc. Amer. Acad. Arts 35: 517. 1900. **Map 1.**

Mex, Mor, Gue and Oax, pine-oak forests, 2000-2600 m; flowering: Aug-Oct. Perennial herbs to 1 m high; leaves with deltoid blades, the petioles mostly 1-3 cm long.

SALVIA PAULWALLERI B.L. Turner, sp. nov. **Fig. 4, Map 8.**

Salviae veronicifoliae A. Gray ex S. Wats. similis sed differt foliis fere deltoideis (vs. ovatis) marginibus minute pubescentibus (vs. ciliatis trichomatibus ca. 2 mm longis).

Perennial (rhizomatous?) herbs to 30 cm high. **Stems** seemingly recumbent, pubescent with both glandular and eglandular hairs ca 1 mm high. **Leaves** mostly 2-3 cm long, 1.5-3.0 cm wide; petioles 2-3 mm long; blades broadly ovate to subdeltoid, sparsely pilose above and below, lower surfaces densely glandular-punctate, the margins serrulate and minutely pubescent. **Spikes** terminal, interrupted, 25-35 cm long; peduncles 7-8 cm long, the rachis with glandular-trichomes 1-2 mm long. **Floral bracts** ovate, soon deciduous. **Flowers** mostly arranged 6 to a node, the nodular gaps 2-6 cm long. **Calyces** (flowering) ca 5 mm long, glandular-pubescent, the upper lip 5-nerved. **Corollas** blue, 10-12 mm long; tubes 6-8 mm long; upper lip ca 3 mm long, sparsely pubescent apically with minute hairs, the lower portion essentially glabrous. **Stylar shaft** flattened, densely pilose apically, the upper branches 2-3 times as long as the lower, deltoid, branches. **Mature nutlets** not observed.

TYPE: MEXICO. DURANGO: Mpio. El Salto, El Salto, pine-oak forests, 8250 ft, 4 Aug 1970, Kathy Shannon 94 (Holotype: TEX).

T.P. Ramamoorthy (by annotation) was the first to suggest novelty status for the present collection. I originally identified the plant as *S. prunifolia* Fernald (= *S. sinaloensis* in the present account), but additional study has led me to concur with the observation of my erstwhile colleague, Ramamoorthy, who has moved on to non-botanical pursuits.

The species is named for Dr. Paul Waller of Austin, Texas, loving mate of my son, Matt Turner, who accompanied me on a trip to Puerto Vallarta to collect the taxon. Unfortunately, time did not permit the venture concerned, mainly because our time was expended in collecting material of *Verbesina jimrobbinsii* B.L. Turner (Phytologia 90: 52-62. 2008), the latter eponym honoring the previous partner of my son Matt, the four of us enjoying a four-day trip to the area concerned.

SALVIA PRUNELLOIDES Kunth, Nov. Gen. Sp. Pl. 2: 289. 1817.
Map 6.

Salvia rhombifolia Sesse & Moc.

Salvia trichandra Briq.

Mic, Mex, Mor and Pue, pine-oak forests, 1500-3400 m; flowering: Sep-Oct.

Perennial rhizomatous herbs to 30 cm high, having terminal interrupted eglandular spikes 20-30 cm long.

According to Epling (1938), This taxon "Passes almost imperceptively into *S. laevis* and *S. pseudocomosa* on the one hand and *S. glechomifolia* on the other."

SALVIA PUSILLA Fernald, Proc. Amer. Acad. Arts 35: 495. 1900.
Map 6.

Oax and Cps, pine-oak forests, 1200-2500 m; flowering: Jul-Sep.

Perennial, rhizomatous, sprawling herbs 10-30 cm high; leaves ovate to subdeltoid, the petioles 2-15 mm long; readily recognized by its short corolla tubes and glandular-pubescent stems and calyces.

SALVIA ROSTELLATA Epling, Repert. Spec. Nov. Regni Veg. Beih. 110: 66. 1938. **Map 2.**

Jal, vicinity of San Sebastian, ca 1500 m; flowering: Jan.
A poorly known taxon, perhaps not separable from *S. sinaloensis*.

SALVIA SETULOSA Fernald, Proc. Amer. Acad. Arts 36: 499. 1901. **Map 7.**

Mic, Mex, Mor, Gue? and Oax, pine-oak forests, 2000-3000 m; flowering: Jul-Oct.

Perennial, rhizomatous, herbs to 60 cm high. A widespread, highly variable, species, best recognized by its elongate spikes, large floral bracts, and setulose pubescence,

SALVIA SINALOENSIS Fernald, Proc. Amer. Acad. Arts 35: 502. 1900. **Map 9.**

Salvia prunifolia Fernald

Sin, Dur, Nay and Jal, pine-oak forests, 1200-2000 m; flowering: Aug-Sep.

Sprawling or semi-prostrate perennial herbs to 60 cm high; leaves highly variable, ovate to oblanceolate, the petioles mostly 2-10 mm long; calyces glandular-pubescent, the corollas blue.

I follow the suggestions of Epling (1939), that *S. prunifolia* is possibly a synonym of the present taxon. See additional comments under *S. assurgens* (above). It is also likely that *S. rostellata* is part of the fabric of *S. sinaloensis*, as noted under the latter.

SALVIA TEXTITLANA B.L. Turner, **sp. nov.** **Fig. 5, Map 8.**

Salviae tricuspidatae Mart. & Gal. similis sed differt foliis longioribus majoribus laminis ovatis 3-7 cm longis (vs. laminis subdeltoideis 2-3 cm longis) subter valde pubescentibus et tubis corollarum 5-6 mm longis (vs. 7-8 mm).

Perennial herbs 50-100 cm high. **Mid-stems** pubescent with arcuate, down-turned white hairs. **Leaves** mostly (4)5-8 cm long, 2-3 cm wide;

petioles 1.5-3.0 cm long. **Capitulescence** a terminal interrupted spike 1-30 cm long; peduncles 2-3 cm long; rachis pubescent with both glandular and eglandular hairs. **Flowers** 4-10 to a node, the nodal gaps 1-3 cm long. **Floral bracts** broadly ovate, soon deciduous. **Calyces** (flowering) 3-4 mm long, glandular-pubescent, the upper lip 5-7 nervate. **Corollas** reportedly blue or "morado;" tubes 5-6 mm long, the lower lip ca as long as the upper, both lips markedly beset with amber globules. **Stamens** inserted at the throat; stamens purple, ca 1 m long. **Stylar shafts** flattened, densely pilose apically, the upper branch 2-3 times as long as the lower, deltoid, branch. **Nutlets** ovoid, ca 2 mm long, 1.5 mm across, the coats smooth, pale tan.

TYPE: MEXICO. OAXACA: Mpio. Santiago Textitlan, "Paraje abajo de El Portillo." 16 43 52 N, 97 24 57.6 W, pine-oak forests, ca 1199 m, 8 Jan 2007, *Idalia Trujillo Olozo 1334* (Holotype: TEX; isotype: MEXU).

ADDITIONAL SPECIMENS EXAMINED: MEXICO. OAXACA: Mpio. Santiago Textitlan, "La Cueva." 16 45 11.5 N, 97 12 44.8 W, ca 2148 m, 7 Sep 2006, *Marcos 474* (TEX); "Paraje Tierra Morada." 16 43 44.3 N, 97 25 2.2W, ca 1792 m, 8 Jan 2007, *Olozo 1286* (TEX); Tierra Blanca." ca 2299 m, 22 Jan 2007, *Salinas 1492* (TEX).

This novelty is clearly closely related to the more northern *Salvia tricuspidata*, to which it is compared in the above diagnosis. It differs in having larger, lanceolate, leaves which are densely pubescent beneath, mainly along the major veins (vs smaller, more nearly subdeltoid blades which are glabrous beneath or nearly so). In addition, the flowers are somewhat smaller.

The species is named, in part, for the Mpio. Santiago Textitlan, whence the type.

SALVIA TRICUSPIDATA Mart. & Gal., Bull. Acad Brux. 11: 78. 1814. **Map 8.**

Oax, pine-oak forests, 2500-3000 m; flowering: Aug-Nov. Suffruticose herbs 30-70 cm high, the leaves broadly ovate to subdeltoid; calyces purple, glandular-pubescent, 5-6 mm long; corollas blue, 12-16 mm long.

SALVIA UNICOSTATA Fernald, Proc. Amer. Acad. Arts 35: 501. 1900. **Map 5.**

Nue, Tam and San, pine and pine-oak forests, 2500-3600 m; flowering: May-Jul.

Small herbs with slender rhizomes, mostly 10-30 cm high.

According to Epling (1939), "save in the glandular pubescence of the inflorescence," this species scarcely differs from some narrow leafed forms of *S. laevis*.

SALVIA VERONICIFOLIA A. Gray ex S. Wats., Proc. Amer. Acad. Arts 22: 144. 1887. **Map 4.**

Jal, known only from the vicinity of Guadalajara, oak forests, mainly in granitic or sandy soils, 1000-1200 m; flowering: Jul-Aug.

Perennial herbs 10-30 cm high; readily recognized by its small ovate leaves with short petioles, and especially by its pubescence: stiffly spreading, glandular, trichomes ca 2 mm high.

SALVIA VILLOSA Fernald, Proc. Amer. Acad. Arts 35: 518. 1900. **Map 9.**

San, known only from the vicinity of Guadalcázar, dry oak forests, ca 1800 m; flowering: Jul-Sep.

Rhizomatous herbs to 30 cm high, the stems markedly villous with glandular hairs.

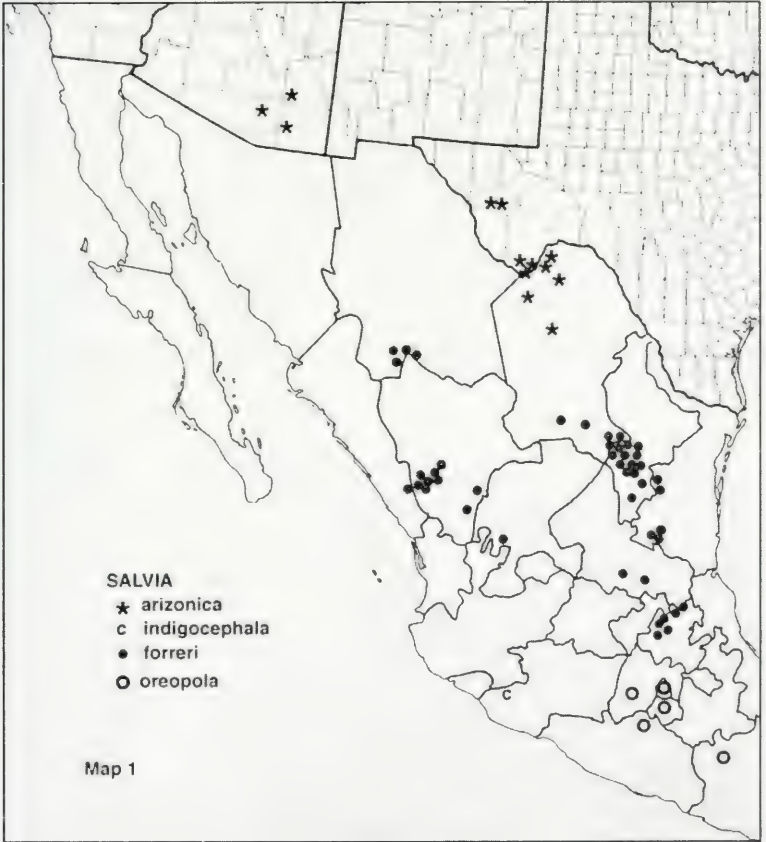
Because of its distinctive pubescence and deep blue flowers, a very distinct species, not likely to be confused with another.

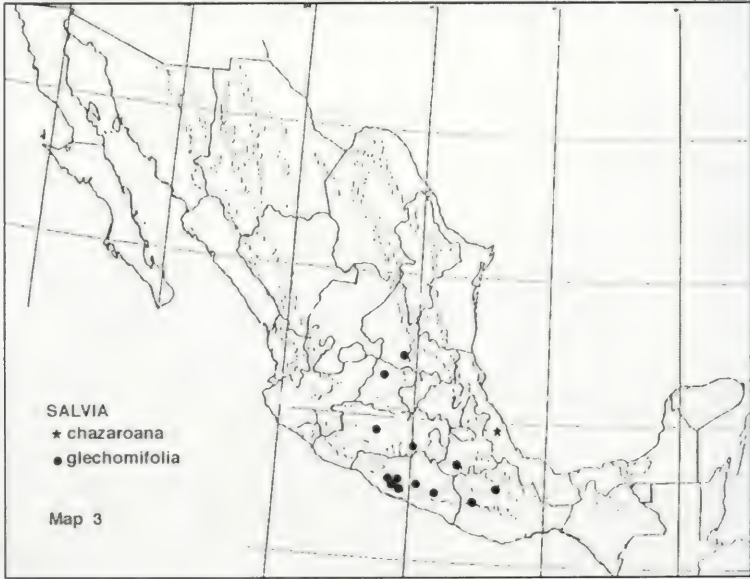
ACKNOWLEDGEMENTS

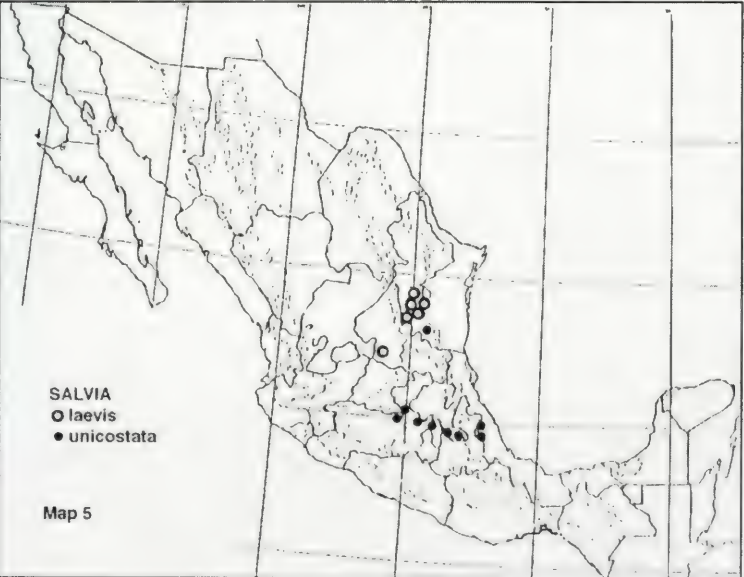
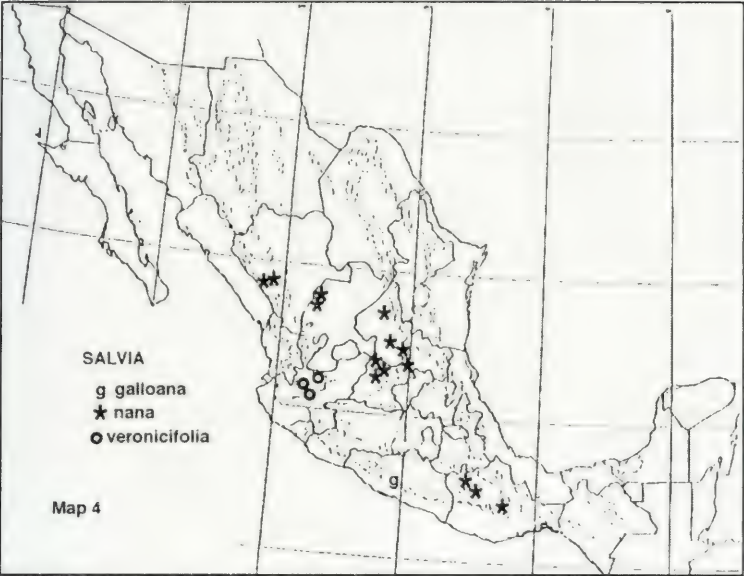
Guy Nesom provided the Latin diagnoses and reviewed the paper, for which I am beholden. Jesus Gonzales and Pablo Carrillo Reyes of GUADA provided helpful input with respect to *S. chazarana*. I am also grateful to Jim Robbins, Paul Waller, and my son Matt Turner for assistance on field work in Mexico during the fall of 2007.

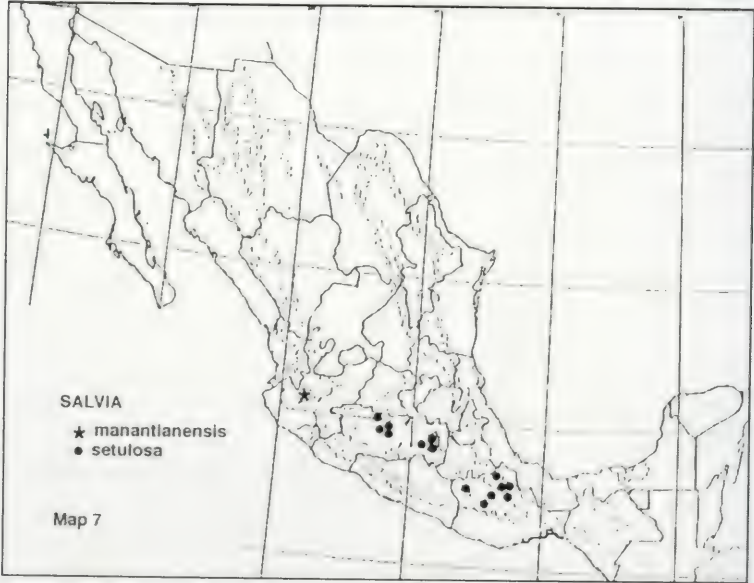
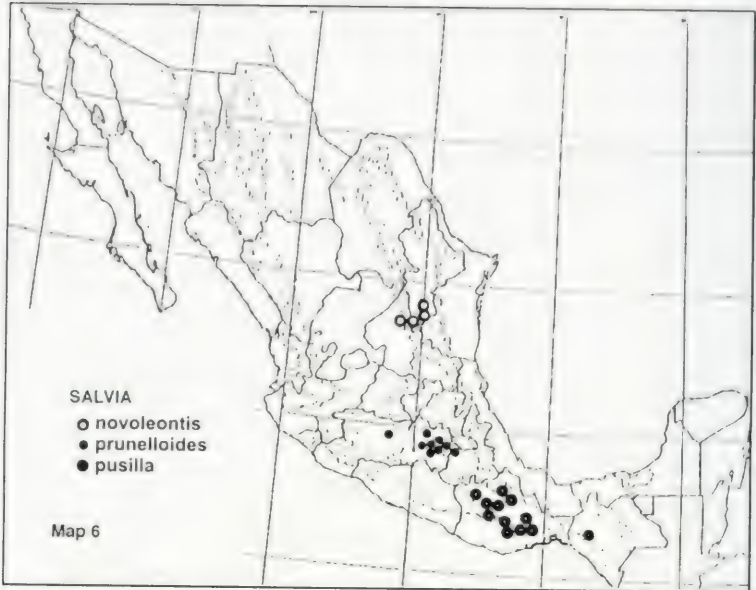
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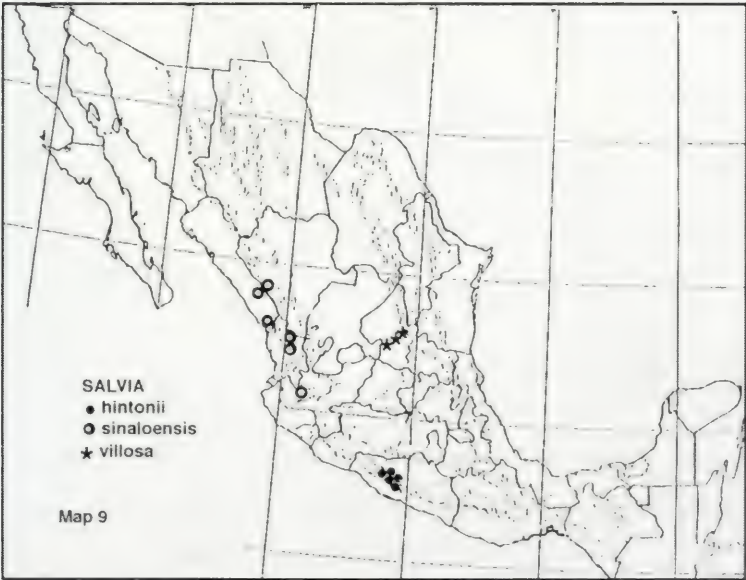
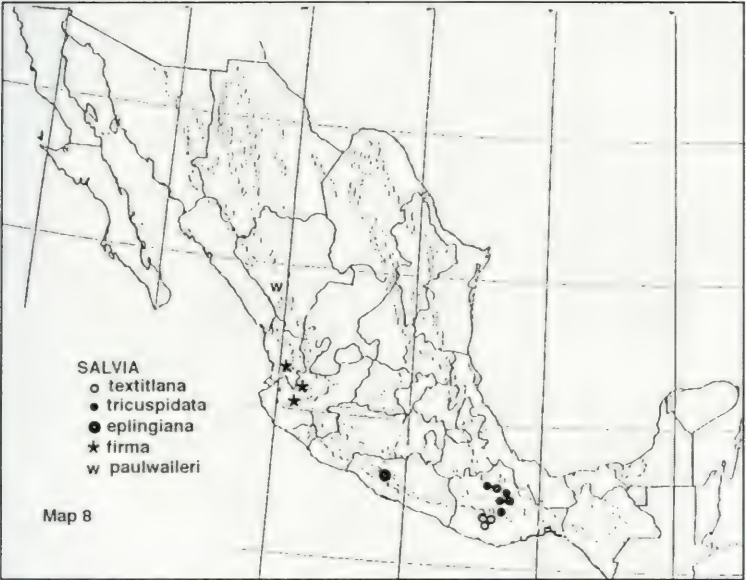




Fig. 1. *Salvia chazaroana* (Isotype: TEX).



Fig. 2. *Salvia galloana* (Holotype: TEX).



Fig. 3. *Salvia novoleontis* (Holotype: TEX).

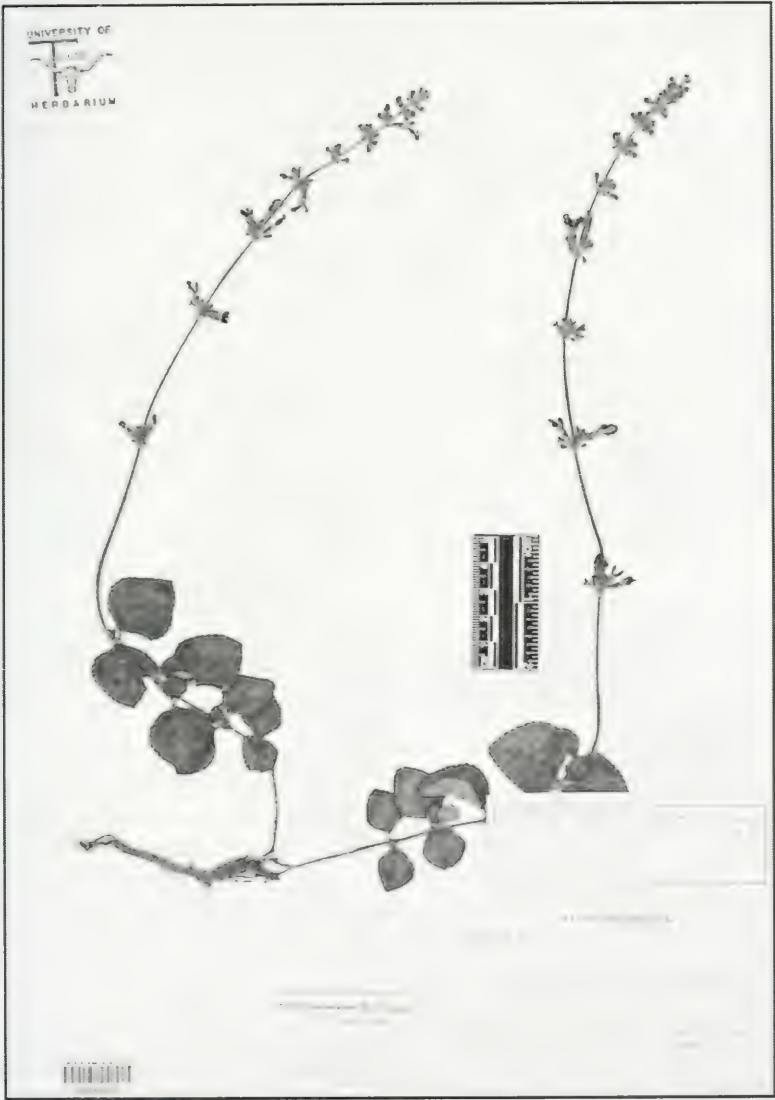


Fig. 4. *Salvia paulwalleri* (Holotype: TEX).



Fig. 5. *Salvia textitlana* (Holotype TEX).

**TAXONOMIC OVERVIEW OF *LIGUSTRUM* (OLEACEAE)
NATURALIZED IN NORTH AMERICA NORTH OF MEXICO**

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ABSTRACT

A key, morphological descriptions, and basic synonymy are provided for the eight species of *Ligustrum* known to be naturalized in North America north of Mexico: *L. japonicum*, *L. lucidum*, *L. obtusifolium* (including *L. amurense*), *L. ovalifolium*, *L. quihoui*, *L. sinense*, *L. tschonoskii*, and *L. vulgare*. Identifications have been inconsistent particularly between *L. sinense* and *L. vulgare* and between *L. japonicum* and *L. lucidum*. The occurrence of *L. quihoui* outside of cultivation in Arkansas, Mississippi, and Oklahoma is documented. *Phytologia* 91(3): 467-482 (December, 2009).

KEY WORDS: *Ligustrum*, Oleaceae, North America, naturalized, taxonomy

The lustrous, mostly evergreen leaves and masses of white, fragrant flowers make privets popular for landscaping and hedges. Many of the species, however, have become naturalized in the USA and Canada and already have proved to be destructive colonizers, especially in the Southeast. Among the naturalized species, European privet (*Ligustrum vulgare*) is native to Europe and northern Africa; all the rest are native to Asia, mainly China, Japan, and Korea.

Many new species and varieties of *Ligustrum* have been described since overviews of Koehne (1904), Lingelsheim (1920), and Mansfield (1924). The genus in eastern Asia has recently been studied by Chang & Miao (1986), and Qin (2009) has provided a taxonomic overview of the whole genus that recognizes 37 species - divided into five sections based primarily on fruit and seed morphology. In Qin's arrangement, among the North American species, sect. *Ligustrum*

includes *L. obtusifolium*, *L. ovalifolium*, *L. tschonoskii*, and *L. vulgare*; sect. *Lucida* X.K. Qin includes *L. lucidum* and *L. quihoui*; and sect. *Sinensia* X.K. Qin includes *L. japonicum* and *L. sinense*.

Hardin (1974) provided a key covering essentially the same species treated here but his couplets emphasized floral characters, which are often unavailable, and descriptions were not given. Characters of leaf persistence in *Ligustrum* also are difficult to evaluate, since almost all of the species are evergreen to some extent, at least in the southeastern USA. Leaves of some species are unambiguously evergreen, e.g., *Ligustrum japonicum* and *L. lucidum*. In others, leaves are thinner, though they may remain green and persistent through the winter, and are characterized here as "deciduous to half-evergreen" or "half-evergreen to evergreen." Some of the variability in leaf persistence, as well as in other features, within species may reflect genotypic variation among cultivars of different provenance, especially within *L. sinense* (see comments below). Variegated leaves occur in some of the species and many of these forms have been named as varieties or forms or given horticultural designations.

The present overview is provided toward clarification of identifications, nomenclature, and geographical ranges prior to publication of the FNANM treatment of Oleaceae. Citations of states are records from specimens studied, except as specifically noted. Citations of phenology, ecology, and distribution generally follow FNA format. Without having studied types, the synonymy given here reflects apparently unambiguous consensus in literature, unless noted otherwise. The synonymy here is not complete, but no comparable summary appears to be available. Synonymy in Chang & Miao (1986) and Qin (2009) is minimal.

KEY TO *LIGUSTRUM* SPECIES NATURALIZED IN NORTH AMERICA NORTH OF MEXICO

1. Leaves (3–)4–13(–15) cm long.
2. Leaves mostly (3–)4–8(–9) cm, primary lateral veins 3–5 pairs, apex acute to abruptly acuminate, abaxial midvein covered by

epidermis; flowers short-pedicellate on pedicels 0.5–2 mm; corolla tube hardly exerted from calyx and ca. equal lobe length.....

.....1. **Ligustrum japonicum**

2. Leaves (4.5–)6–13(–15) cm, primary lateral veins (5–)6–8 pairs, apex usually long-acuminate, abaxial midvein not covered by epidermis; flowers subsessile on pedicels 0–0.5 mm; corolla tube distinctly exerted from calyx and ca. 2 times longer than lobes

.....2. **Ligustrum lucidum**

1. Leaves 1.5–6(–6.5) cm long.

3. Branchlets completely glabrous, usually glossy

.....6. **Ligustrum ovalifolium**

3. Branchlets minutely hirtellous, hirsute-hirtellous, or hirsutulous, dull.

4. Leaf blades sparsely to moderately hirsutulous to hirsute-strigose on both surfaces, sometimes only along the veins, sometimes mostly near the margins, margins appressed-ciliate, primary lateral veins (5–)6–8 pairs, apices sharply acute and usually at least slightly acuminate, rarely obtuse

.....8. **Ligustrum tschonoskii**

4. Leaf blades glabrous on both surfaces or sometimes sparsely hairy along the abaxial midvein, sometimes minutely and indistinctly hirtellous adaxially, margins glabrous to glabrate, primary lateral veins (2–)3–6 pairs, apices obtuse to acute (*L. vulgare*) or obtuse to rounded, rarely slightly retuse.

5. Leaf blades narrowly oblong-elliptic to oblanceolate-elliptic, oblanceolate or narrowly obovate, usually broadest slightly above the middle; inflorescence usually of stiffly spreading, narrowly cylindric branches, flowers sessile to subsessile in verticil-like clusters

.....3. **Ligustrum quihoui**

5. Leaf blades variously shaped; inflorescence broadly cylindric to pyramidal, flowers sessile to pedicellate in columnar to broadly cylindric or narrowly pyramidal to open-pyramidal panicles of cymes.

6. Inflorescence diffuse and open panicles terminal and on lateral branches interspersed with non-flowering branches; corolla tube slightly shorter than lobes, usually barely exerted from the calyx tube. 4. **Ligustrum sinense**

6. Inflorescence terminal, mostly a compact panicle; corolla tube equal or longer than the lobes, distinctly exerted from the calyx tube.

7. Branchlets hirsute-hirtellous with hairs of uneven length; leaf blade apices asdfasdf; corolla tube 1.5–3 times longer than the lobes

..... 7. **Ligustrum obtusifolium**

7. Branchlets glabrous to evenly and minutely hirtellous to hirsutulous with straight to upcurved hairs of relatively even length; leaf blade apices obtuse to acute; corolla tube equal the lobes or slightly shorter

..... 5. **Ligustrum vulgare**

1. **Ligustrum japonicum** Thunb., Nova Acta Regiae Soc. Sci. Upsal. 3: 207. 1780.

Ligustrum japonicum var. *rotundifolium* Blume, Mus. Bot. Lugd.-Bat. 1: 313. 1850.

Ligustrum coriaceum Carrière, Rev. Hort., 418, plate 56. 1874.

Ligustrum lucidum var. *coriaceum* (Carrière) Decne., Fl. Serres 22: 8. 1877.

Ligustrum japonicum var. *pubescens* G. Koidzumi, Bot. Mag. (Tokyo) 30: 82. 1915.

Ligustrum japonicum var. *crassifolium* Hisauchi, J. Jap. Bot. 11: 848. 1935.

Ligustrum japonicum var. *pricei* (Hayata) T.S. Liu & J.C. Liao, Quart. J. Taiwan Mus. 31: 292. 1978.

Shrubs or small trees 1–4 m. **Branchlets** usually glabrous or sometimes minutely puberulent. **Leaves** evergreen; blades broadly ovate to elliptic-ovate, (3–)4–8(–9) cm x 22–50 mm, glabrous, primary lateral veins 3–4(–5) pairs, abaxial midvein covered by epidermis, apex acute to abruptly acuminate, margins glabrous. **Inflorescence** terminal, broadly pyramidal, 6–15 cm. **Flowers** short-pedicellate, pedicels 0.5–2 mm, glabrous; calyx glabrous; corolla tube equalling or slightly longer

or shorter than lobes, lobes reflexing and not reaching calyx or barely so. **Drupes** globose to oblong or slightly ellipsoid, 7–8 mm; seeds 1–2, endocarp stony, not channeled. $2n = 22, 44, 46$. **Japanese Privet**

Flowering Apr–Jun. Fencerows, lots, woods edges; 10–300 m; Ala., Ark., Fla., Ga., La., Miss., S.C., Tenn., Tex., Va.; native to Japan and Korea; introduced also in West Indies (Puerto Rico), Africa, Australia, Pacific Islands (Hawaii). The PLANTS Database (USDA, NRCS 2009) shows *L. japonicum* in Md. and N.C., and Calflora (www.calflora.org) has records for California.

Ligustrum japonicum occasionally establishes itself outside of cultivation, but it is not nearly as common or invasive, or as fecund, as *L. lucidum*. As noted by Jefferson (1976), *L. japonicum* is hardy into New England, while *L. lucidum* usually is not hardy north of Washington, D.C.

2. **Ligustrum lucidum** W.T. Aiton, Hort. Kew. (ed. 2) 1: 19. 1810.

Ligustrum japonicum var. *macrophyllum* Decne., Fl. Serres 22: 8. 1877.

Shrubs or small trees 2–5+ m. **Branchlets** glabrous. **Leaves** evergreen; blades ovate to elliptic-ovate, ovate-lanceolate, or elliptic, (4.5–)6–13(–15) cm x 25–55(–62) mm, glabrous, primary lateral veins (5–)6–8 pairs, abaxial midvein not covered by epidermis, apex long acute-acuminate or less commonly acute (in smaller leaves), margins glabrous. **Inflorescence** terminal, broadly pyramidal, 7–16(–20) cm. **Flowers** sessile to subsessile, pedicels 0–0.5 mm, glabrous; calyx glabrous; corolla tube about equal or slightly shorter than the lobes. **Drupes** globose to depressed-globose, sometimes curved-obovoid or reniform, 5–9(–10) mm; seeds 1–2(–3), endocarp stony, with several longitudinal channels. $2n = 46$. **Glossy Privet, Broad-leaf privet**

Flowering Apr–Jun. Fencerows, lots, waste areas, deciduous woods, woods edges; 10–300 m; Ala., Ark., Calif., Fla., Ga., La., Md., Miss., N.C., S.C., Tex.; native to China; introduced also in Mexico (Coahuila, San Luis Potosí, Veracruz), West Indies (Puerto Rico), South America (Brazil), Europe (Portugal), Africa, Asia, Australia, Pacific Islands (Hawaii).

In Texas, Louisiana, and southern Arkansas, at least, *Ligustrum lucidum* is becoming a highly invasive weed, commonly seen as multi-stemmed clumps, in Texas commonly up to 4 or 5 meters

tall. Jefferson (1976) included a photo of an arboretum plant in Arcata, California, that appears to be about 15 meters. Collections with small leaves sometimes are misidentified as *L. japonicum*, but blades of smaller leaves of *L. lucidum* are usually more ovate with 5(–6) pairs of lateral veins. Smaller leaves commonly are produced on plants bearing much larger ones.

A recently described variety of *Ligustrum lucidum* from China (var. *xideense* J.L. Liu; Liu 2004) is said to differ from typical plants in its narrower (0.6–3.7 cm wide), lanceolate to elliptic-lanceolate leaves with fewer pairs of primary lateral veins (2–5(–6) pairs).

3. *Ligustrum quihoui* Carrière, Rev. Hort. 1869: 377. 1869.

Ligustrum brachystachyum Decne., Nouv. Arch. Mus. Hist. Nat. Ser. 2, 2: 34. 1879.

Shrubs 1–3 m. **Branchlets** below the inflorescence minutely puberulent to hirtellous in 2 lines, or evenly puberulent to hirtellous proximally and distally. **Leaves** half evergreen to evergreen; blades narrowly elliptic, rhombic-elliptic, oblanceolate-elliptic to obovate-elliptic, oblanceolate, or narrowly obovate, mostly commonly broadest slightly above the middle, often slightly falcate, (1.5–)2–4.5(–5.5) cm x 5–15(–25) mm, glabrous or rarely puberulent along the abaxial midvein, primary lateral veins 2–4(–5) pairs, very rarely (5–)6–8(–9) pairs, abaxial midvein not covered by epidermis, apex usually acute but obtuse to rounded or slightly retuse in broadest blades, margins glabrous. **Inflorescence** terminal on stiffly spreading, narrowly cylindric lateral branches, 4–15(–22) cm, less commonly with sessile flowers on short branches spreading from a central axis and the whole inflorescence appearing narrowly pyramidal and terminal, 8–20 cm. **Flowers** sessile to subsessile, usually in verticil-like clusters along the inflorescence axis, pedicels 0–0.5(–1) mm, puberulent; calyx glabrous; corolla tube ca. equal the lobes. **Drapes** obovoid or ellipsoid to subglobose, 4–7(–9) mm; seeds 1–2, endocarp stony, with several longitudinal channels. $2n = ?$ **Waxy-leaf Privet**

Flowering May–Jul. Fencerows, lots, waste areas, roadsides, deciduous woods, woods edges, thickets, creek banks; 10–300 m; Ark., Fla., Md., Miss., N.C., Okla., Tex., Va.; native to China.

Ligustrum quihoui is recognized by its stiffly spreading branches, narrowly cylindric inflorescence branches with flowers in

verticil-like clusters, and relatively thick, deep green, rhombic-elliptic to oblanceolate-elliptic or obovate-elliptic leaves. It is not often misidentified. At least in Travis, Tarrant, and Dallas counties, Texas, it is an extremely aggressive colonizer capable of forming dense thickets.

First records for the species naturalized in Mississippi and Oklahoma are recorded here:

Mississippi. Pike Co.: beside US Hwy 98 at McComb, 20 Jun 1969, *R.D. Thomas 14179* (NLU).

Oklahoma. Cleveland Co.: [Norman], Sutton Urban Wilderness Park, edge of larger lake, edge of low woods, common, 5 Jun 1996, *Folley 1830* (OKL). The **Arkansas** record is documented here: Pulaski Co.: Allsopp Park -- south unit, naturalized in mixed pine-oak-hickory forest on shale and sandstone substrate, especially along trails, *T. Witsell 03-0007* with J. Peck (UARK). Good photos of Arkansas plants of *Ligustrum quihoui*, as well as other privets, are shown by Serviss (2009).

4. *Ligustrum sinense* Lour., Fl. Cochinch. 1: 19. 1790.

Shrubs 1–3(–6) m, aggressively colonial from root sprouts.

Branchlets minutely hirtellous to hirsutulous or substrigose with straight or upcurved hairs sometimes of uneven length. **Leaves** half evergreen to evergreen; blades broadly elliptic or ovate-elliptic to oblong-ovate, elliptic-lanceolate, or suborbicular, (1.5–)2–4 cm x 10–20 mm, glabrous except for sparsely hirsutulous to puberulent abaxial midvein, sometimes minutely and indistinctly hirtellous adaxially, primary lateral veins (3–)4–5 pairs, abaxial midvein not covered by epidermis, apex obtuse to rounded or retuse, margins glabrous to glabrate. **Inflorescence** diffuse and open-pyramidal, 4–11 cm, usually numerous on lateral branches commonly leafless or few-leaved at base, flowering lateral branches interspersed with non-flowering branches. **Flowers** pedicellate, pedicels 1–5 mm, glabrous; calyx glabrous to sparsely puberulent; corolla tube slightly shorter than lobes, usually barely exerted from the calyx tube. **Drupe**s subglobose to obovoid, (4–)5–7 mm; seeds 1, endocarp stony, not channeled. $2n = 46$.

Chinese Privet

Flowering Apr–May(–Jun). Open and shaded disturbed areas, fencerows, river and stream floodplains, bottomland forests, lake shores, swamp and marsh edges, upland hammocks, pinelands; 10–300 m; Ala., Ark., Conn., Fla., Ga., Ky., La., Md., Mass., Miss., Mo., N.J.,

N.C., Okla., R.I., S.C., Tenn., Tex., Va.; native to China, Vietnam, and Laos; introduced also in West Indies, Mexico (Veracruz), Europe, Africa, Indian Ocean Islands, Australia, Pacific Islands.

At least in North Carolina and Missouri, some plants identifiable as *Ligustrum sinense* have with elliptic-lanceolate leaf blades with acute apices and mostly terminal inflorescences, apparently lacking the numerous lateral flowering branches. Vestiture on these plants is characteristic of the species elsewhere. In Louisiana and Texas, some populations produce leaves variably broadly to narrowly elliptic (tapering at both ends) and that also are variable in thickness.

Following Hao and Zhang (1993), Chang et al. (1996) recognized 8 varieties of *Ligustrum sinense* based on variation in vestiture, leaf shape and other foliar features, and position and leafiness at base of the inflorescence. The biological reality of these taxa is not clear, however, since all except var. *coryanum* (W.W. Smith) Hand.-Mazz. appear to be sympatric with the widespread var. *sinense*. Plants in the USA appear to have a mixture of features characterizing var. *myrianthum* (Diels) Hoefker (panicles axillary or rarely terminal, not leafy at base, or rarely leafy; leaf veins usually not sunken adaxially; calyx glabrous) and var. *sinense* (branchlets and inflorescence rachis usually densely pubescent or pilose; leaf blades ovate to oblong or suborbicular, sparsely pubescent or glabrescent abaxially).

5. *Ligustrum vulgare* L., Sp. Pl. 1: 7. 1753.

Shrubs 1.5–5 m. **Branchlets** glabrous to evenly and minutely hirtellous to hirsutulous with straight to upcurved hairs of relatively even length. **Leaves** half evergreen to evergreen; blades elliptic-lanceolate to elliptic-ovate, 3–5.5(–6) cm x 10–25 mm, glabrous except for the abaxial midvein sometimes with a few scattered hairs, primary lateral veins 4–6 pairs, abaxial midvein not covered by epidermis, apex obtuse to acute, margins glabrous to glabrate. **Inflorescence** terminal, compactly narrowly pyramidal to broadly cylindric, 4.5–5.5 cm. **Flowers** short-pedicellate, pedicels 0.5–1 mm, minutely hirtellous; calyx glabrous; corolla tube equal the lobes or slightly shorter. **Drupe**s globose, 4–6 mm; seeds 2–4, endocarp membranaceous, not channeled. $2n = 46$. **Common Privet, European Privet**

Flowering (May–)Jun–Jul. Fencerows, thickets, roadsides, disturbed sites, open woods; 50–500(–1600 in western states) m; B.C.,

Ont.; Ark., Calif., Conn., Ga., Idaho, Ill., Ind., Ky., Me., Md., Mass., Mich., Mo., N.H., N.J., N.Y., N.C., Ohio, Oregon, Pa., R.I., Vt., Va., W.Va.; native to Europe and northern Africa; introduced also in South America (Ecuador), Asia (Japan), Africa, Pacific Islands (New Zealand), Australia. The PLANTS Database also records the presence of *L. vulgare* in (eastern USA) Ala., Del., D.C., Ill., Iowa, La., S.C., Tenn., Tex., and Wis. and (western USA) Colo., Mont., Nebr., N.Mex., and Utah. In the present study, no collections of *L. vulgare* have been seen among many of the genus studied from Alabama, Louisiana, Tennessee, and Texas, and it is unlikely that the species is naturalized in those states.

6. **Ligustrum ovalifolium** Hassk., Cat. Hort. Bot. Bogor. 119. 1844.

Ligustrum japonicum var. *ovalifolium* (Hassk.) Blume, Mus. Bot.

Lugd.-Bat. 1: 313. 1850.

Ligustrum californicum Decne., Fl. Serres 22: 5. 1877.

Ligustrum medium Franch. & Sav., Enum. Pl. Jap. 2: 437. 1878.

Shrubs 2–5 m. **Branchlets** glabrous-shiny, rarely hirtellous in lines. **Leaves** half evergreen to evergreen; blades ovate to elliptic-ovate, broadly elliptic, or elliptic, 2.5–5(–6.5) cm x 15–33 mm, glabrous, primary lateral veins (2–)3–6 pairs, apex acute to abruptly acuminate, margins glabrous. **Inflorescence** subcylindric to narrowly to broadly pyramidal, 4–7 cm. **Flowers** short-pedicellate, pedicels 0.5–1 mm, glabrous; calyx glabrous; corolla tube 2–3 times longer than lobes. **Drupe**s ovoid, 6–8 mm; seeds 1(–2), endocarp stony, not channeled. $2n = 22, 46$. **California Privet**

Flowering (Dec)Apr–Jul. Fencerows, thickets, roadsides, disturbed sites; 100–600 m; Ala., Fla., Ga., Ky., Md., Mich., Mo., N.J., N.C., Ohio, Pa., Tenn., W.Va., Va.; native to Japan and Korea; introduced also in West Indies (Puerto Rico), Europe, Africa, Australia, Pacific Islands (New Zealand). The PLANTS Database also records the presence of *L. ovalifolium* in Ont., Calif., Conn., Del., D.C., Mass., and Tex. The record for Ontario is from a plant apparently persisting from cultivation (fide Luc Brouillet, 2009). I have not seen a voucher from Texas and its occurrence there outside of cultivation is unlikely.

Three varieties within *Ligustrum ovalifolium* were recognized by Noshiro (1985), each restricted in native range to Japan. Var. *hisauchii* (Makino) S. Noshiro has leaves sparsely hairy along the

abaxial midvein; var. *pacificum* (Nakai) Mizushima is an insular entity with slightly larger leaves and shorter corolla tubes.

Ligustrum ovalifolium, *L. obtusifolium* and *L. tschonoskii* are the species naturalized in the USA with corolla tubes longer than the lobes. *Ligustrum vulgare* also apparently is closely related to this group, although its corolla tubes are somewhat shorter. These four species can be distinguished by the following key.

a. Branchlets glabrous, rarely hirtellous in lines, glossy; leaf blades with (2–)3–6 pairs of primary lateral veins..... **Ligustrum ovalifolium**

a. Branchlets evenly hirsute-hirtellous or puberulent to pilosulous, dull; leaf blades with 4–8 pairs of primary lateral veins.

b. Leaf blades sparsely to moderately hirsutulous to hirsute-strigose on both surfaces, sometimes only along the veins, sometimes mostly near the margins, margins appressed-ciliate; blade apices sharply acute and usually at least slightly acuminate, rarely obtuse; inflorescence terminal.....**Ligustrum tschonoskii**

b. Leaf blades usually glabrous on both surfaces or sometimes sparsely hairy along the abaxial midvein, sometimes minutely and indistinctly hirtellous adaxially, margins glabrous; blade apices obtuse to rounded (*L. obtusifolium*) or obtuse to acute (*L. vulgare*); inflorescence terminal (*L. vulgare*) or terminal and axillary, commonly on lateral shoots (*L. obtusifolium*).

c. Blade apices obtuse to acute; branchlets glabrous to evenly and minutely hirtellous to hirsutulous with straight to upcurved hairs of relatively even length; inflorescence terminal, compactly narrowly pyramidal to broadly cylindric

.....**Ligustrum vulgare**

c. Blade apices obtuse to rounded, sometimes slightly retuse; branchlets hirsute-hirtellous with hairs of uneven length; inflorescence terminal or terminal and axillary, commonly on lateral shoots, columnar to narrowly pyramidal

.....**Ligustrum obtusifolium**

7. **Ligustrum obtusifolium** Sieb. & Zucc., Abh. Math.-Phys. C.

Königl. Bayer. Akad. Wiss. 4: 168. 1846. *Ligustrum ibota*

var. *obtusifolium* (Sieb. & Zucc.) G. Koidzumi, Bot. Mag. (Tokyo) 40: 342. 1926.

Shrubs 2–3 mm. **Branchlets** hirsute-hirtellous with hairs of uneven length. **Leaves** deciduous to half evergreen; blades elliptic to ovate-elliptic, oblong-ovate, or elliptic-obovate, 2.5–6 cm x (8–)12–26 mm, glabrous or uncommonly sparsely puberulent to villous, primary lateral veins 4–7 pairs, abaxial midvein not covered by epidermis, apex obtuse to rounded, sometimes slightly retuse, margins glabrous to glabrate. **Inflorescence** terminal or terminal and axillary, commonly on lateral shoots, short-columnar or subcapitate to narrowly pyramidal, 1.5–5 cm. **Flowers** subsessile to short-pedicellate, pedicels (0–)0.5–2 mm, glabrous to hirtellous; calyx glabrous to hirtellous; corolla tube 1.5–3 times longer than lobes. **Drupes** subglobose to broadly ellipsoid, 5–8 mm; seeds 1, endocarp stony, not channeled.

1. Leaf blades usually sparsely villous abaxially; calyx and pedicels densely to moderately or sparsely hirtellous, occasionally nearly glabrous; corolla tube 2–3 times longer than the lobes

.....7a. **L. obtusifolium** var. **obtusifolium**

1. Leaf blades usually glabrous abaxially; calyx and pedicels glabrous to very sparsely hirtellous; corolla tube 1.5–2 times longer than the lobes.....7b. **L. obtusifolium** var. **suave**

7a. **Ligustrum obtusifolium** var. **obtusifolium**

Ligustrum obtusifolium var. *leiocalyx* (Nakai) H. Hara, J. Jap. Bot. 20: 329. 1944. *Ligustrum tschonoskii* var. *leiocalyx* Nakai, Trees Shrubs Jap., 276. 1922. *Ligustrum ibota* var. *leiocalyx* (Nakai) Nakai, Trees Shrubs Jap. (prop. rev. ed.) 1: 365. 1927. *Ligustrum obtusifolium* f. *leiocalyx* (Nakai) G. Murata, Acta Phytotax. Geobot. 19: 71. 1962.

Ligustrum regelianum Koehne in Urban et al., Festschr. Ascherson 192. 1904 (non Lemoine ex Dippel [pro syn.], Handb. Laubholz. 1: 133. 1889). *Ligustrum ibota* var. *regelianum* (Koehne) Rehder in Bailey, Cycl. Amer. Hort. 2: 912. 1900. *Ligustrum obtusifolium* var. *regelianum* (Koehne) Rehder, Möller's Deutsche Gärtn.-Zeit. 14: 218. 1899.

Ligustrum obtusifolium var. *velutinum* (Blume) H. Hara, J. Jap. Bot. 20: 329. 1944. *Ligustrum obtusifolium* f. *velutinum* (Blume) G.

Murata, Acta Phytotax. Geobot. 19: 72. 1962. *Ligustrum ibota* var. *velutinum* Blume, Mus. Bot. Lugd.-Bat. 1: 312. 1850.

Leaf blades usually sparsely villous abaxially; calyx and pedicels densely to moderately or sparsely hirtellous, occasionally nearly glabrous; corolla tube 2–3 times longer than the lobes. $2n = 46$.

Border Privet

Flowering May–Jun. Fencerows, woods edges, roadsides, old home sites, disturbed sites; 100–600 m; Conn., Ill., Ky., Md., Mass., Mich., Mo., N.J., N.Y., N.C., Ohio, Pa., R.I., Tenn., Va., W.Va.; native to Japan and Korea. The PLANTS Database also records the presence of var. *obtusifolium* in D.C., Iowa, Ind., N.H., N.J., and Vt.

7b. *Ligustrum obtusifolium* var. *suave* (Kitagawa) H. Hara, J. Jap.

Bot. 20: 329. 1944. *Ligustrum ibota* Sieb. & Zucc. var. *suave* Kitagawa, Bot. Mag. (Tokyo) 48: 612. 1934. *Ligustrum obtusifolium* subsp. *suave* (Kitagawa) Kitagawa, J. Jap. Bot. 40: 134. 1965. *Ligustrum suave* (Kitagawa) Kitagawa, Neo-Lineam. Fl. Mansh., 510. 1979.

Ligustrum amurense Carrière, Rev. Hort. 1861: 352. 1861. *Ligustrum ibota* var. *amurense* (Carrière) Mansf., Bot. Jahrb. Syst. 59, 132: 65. 1924.

Leaf blades usually glabrous abaxially; calyx and pedicels glabrous to very sparsely hirtellous; corolla tube 1.5–2 times longer than the lobes. $2n = 46$. **Amur Privet**

Flowering May–Jun(–Jul). Fencerows, old home sites, disturbed sites; 100–600 m; Ill., Md., Mass., Tenn.; native to China and at least the Amur region of southeastern Russian. The PLANTS Database also records the presence of var. *amurense* in Ala., Ark., Ky., Md., Maine, N.J., N.Y., N.C., Pa., S.C., Tex., Va., and W.Va.

Chang and Miao (1986) restricted the concept of native var. *obtusifolium* to Japan, var. *suave* to China, mostly as in the key above. They noted that typical *L. obtusifolium* is variable in calyx vestiture and recognized glabrous and hairy calyces within var. *obtusifolium*. In Japan, plants of *L. obtusifolium* with glabrous calyces occur with the typical (hairy) form and were identified by Ohwi (1965) as *L. obtusifolium* var. *leiocalyx*. In Madison Co., Kentucky, calyx vestiture in *L. obtusifolium*-like plants varies from glabrate (Taylor & Thompson 1504, NLU) to minutely hispidulous (Taylor & Thompson 1504, NLU);

Taylor 1446, NLU); in Oldham Co., Kentucky, a collection has hirsute calyces (Duncan 22754, NLU).

Var. *suave* has generally been recognized at specific rank (as *Ligustrum amurense*) in the United States, differing from *L. obtusifolium* by its glabrous calyx and thicker, more persistent leaves (Bailey 1950; Hardin 1974; Gleason & Cronquist 1991). But because the density of calyx vestiture in typical *L. obtusifolium* is variable and assessment of leaf thickness usually is subjective and inconsistent, many identifications of *L. obtusifolium* and *L. amurense* probably have been confused. Chang and Miao (1986) noted that variation occurs in the Chinese populations and some plants of var. *suave* approach var. *obtusifolium* in corolla proportions and leaf vestiture.

Ligustrum amurense was treated in the Flora of China (Chang et al. 1996) as *L. obtusifolium* subsp. *suave*, because of the recognition of yet another infraspecific taxon — *L. obtusifolium* subsp. *microphyllum* (Nakai) P.S. Green (*L. ibota* var. *microphyllum* Nakai), which occurs in China, Japan, and Korea. The plants are small shrubs with leaf blades 0.8–3 x 0.4–1.3 cm and have corolla tubes 2.5 times longer than the lobes.

The status of *Ligustrum ibota* Sieb. & Zucc. of Japan and Korea is unresolved. Mansfeld (1924) treated *L. obtusifolium* and *L. ibota* as synonymous. When maintained as distinct from *L. obtusifolium* (e.g., Rehder 1940; Chang & Miao 1986; Qin 2009), *L. ibota* is said to differ in its shorter, nearly capitate inflorescence (flowers 4–8). Both species have variably hairy calyces. All or almost all of the GH collections originally identified as *L. ibota* are *L. obtusifolium*.

a. Inflorescence 1.5–5 cm long; leaf blade apices usually obtuse; corolla tubes 6–7 mm long, lobes 2–3 mm long; calyx glabrous to hirsute

.....**Ligustrum obtusifolium**

a. Inflorescence 1.5–2 cm long; leaf blade apices usually acute; corolla tubes 5–6 mm long, lobes 1.5–2.5 mm long; calyx hirsute

.....**Ligustrum ibota**

Ligustrum ibota Sieb. & Zucc., Abh. Bayer. Akad. Wiss., Math.-Naturwiss. Abt. 4(3): 167. 1846.

Ligustrum ciliatum Sieb. ex Blume, Mus. Bot. Lugd.-Bat. 1: 312. 1850.

Ligustrum ibota var. *ciliatum* (Sieb. ex Blume) Decne., Nouv.

Arch. Mus. Paris ser 2, 2: 18. 1878. *Ligustrum ibota* Sieb. ex

Sieb. & Zucc. (Verh. Batav. Gen. 12: 36. 1830, nomen nudum) is a synonym of *L. obtusifolium* (fide Rehder 1921 (p. 50); Chang & Miao 1986; Green 1995), in contrast to *L. ibota* Sieb. & Zucc. 1846. In the Flora of Japan, Noshiro (1993), treated *L. ibota* Sieb. ex Sieb. & Zucc. (including *L. ciliatum* as a synonym) as a distinct species but not *L. ibota* Sieb. & Zucc.

8. ***Ligustrum tschonoskii*** Decne., Nouv. Arch. Mus. Hist. Nat. Ser. II, 2: 18. 1879. *Ligustrum ibota* var. *tschonoskii* (Decne.) Nakai, Fl. Kor. 2: 89. 1911. *Ligustrum ibota* f. *tschonoskii* (Decne.) Nakai, Bot. Mag. (Tokyo) 32: 124. 1918. *Ligustrum ciliatum* var. *tschonoskii* (Decne.) Mansf., Bot. Jahrb. Syst. 59, 132: 67. 1924.

Ligustrum acuminatum Koehne in Urban & K. Graebner, Festschr. Ascherson, 201. 1904.

Ligustrum macrocarpum Koehne in Urban & K. Graebner, Festschr. Ascherson, 201. 1904. *Ligustrum acuminatum* var. *macrocarpum* (Koehne) C.K. Schneid., Ill. Handb. Laubholzk. 2: 807. 1911. *Ligustrum ciliatum* var. *macrocarpum* (Koehne) Mansf., Bot. Jahrb. Syst. 59, 132: 68. 1924.

Ligustrum tschonoskii var. *glabrescens* G. Koidzumi, Bot. Mag. (Tokyo) 30: 82. 1916. *Ligustrum tschonoskii* f. *glabrescens* (G. Koidzumi) G. Murata, Acta Phytotax. Geobot. 25: 35. 1972.

Ligustrum yesoense Nakai, Trees & Shrubs Jap., 278. 1922.

Ligustrum kiyozumianum Nakai, Trees & Shrubs Jap. (rev. ed.), 376, fig. 177. 1927.

Shrubs 1–3(–4) m. **Branchlets** puberulent to pilosulous. **Leaves** deciduous to half evergreen; blades elliptic to broadly elliptic, elliptic-obovate, or ovate-lanceolate, 2–5(–6) cm x 13–30 mm, sparsely to moderately hirsutulous to hirsute-strigose on both surfaces, sometimes only along the veins, sometimes mostly near the margins, primary lateral veins (5–)6–8 pairs, abaxial midvein not covered by epidermis, apex sharply acute and usually at least slightly acuminate, rarely obtuse, margins appressed-ciliate. **Inflorescence** terminal, broadly cylindric to pyramidal, 3–5 cm. **Flowers** subsessile to subsessile, pedicels 0–0.5(–1) mm, pilosulous; calyx glabrous; corolla tube 1.5–2 times longer than lobes. **Drupe**s ovoid to globose, 6–8(–12, rarely) mm; seeds 1(–2), endocarp stony, not channeled. $2n = 44, 46$.
Tschonosky Privet

Flowering Jun–Jul. Deciduous woods; ca. 100 m; D.C.; native to Japan and Korea.

Ligustrum tschonoskii is known in North America only from the woods along the bank of Rock Creek in Rock Creek Park (Shetler & Orli 2000). Two varieties within the species were recognized by Noshiro (1985), distinguished by slight and overlapping size differences. Var. *tschonoskii* is restricted in native range to Japan; var. *kiyozumianum* (Nakai) Ohwi occurs in Japan and Korea.

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**ADDITIONS TO THE GENUS *ORBIVESTUS* H. Rob.
(ASTERACEAE:VERNONIEAE) AND NEOTYPIFICATION OF
VERNONIA TEITENSIS O. HOFFM.**

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ABSTRACT

Orbivestus H. Rob. is redefined as having divaricately seriate-cymose branching in the inflorescence. Eleven species are included, and five species, *O. catumbensis* (Hiern) H. Rob., *O. leopoldii* Vatke, *O. teitensis* (Hoffm.) H. Rob., *O. turbinata* (Oliv. & Hiern) H. Rob., and *O. unionis* (Sch.Bip. ex Walp.) H. Rob. are added to the genus while *V. undulata* Oliv. & Hiern is provisionally rejected. Neotypes are selected for *Vernonia teitensis* Hoffm., *V. johannis* O. Hoffm. and *V. pilgeriana* Muschl., whose types were destroyed in Berlin. *Phytologia* 91(3): 483-493 (December, 2009).

KEY WORDS: *Orbivestus*, *Vernonia teitensis*, neotypes, Africa, Vernonieae, Asteraceae.

Previous attempts by the author to resolve the relationships of African Vernonieae have resulted in some over simplifications (Robinson 1999) and left many of the species unresolved. The most recent efforts, presented here, have relied on a character previously noted mostly in Western Hemisphere members of the tribe but rare in the Eastern Hemisphere. A related group of species is here recognized based on divaricately seriate-cymose branching of the inflorescence.

The divaricate seriate-cymose branching of the ultimate branches of the inflorescence is almost unique in the tribe to New World members of the Vernonieae. As illustrated by Cabrera (1944), the seemingly sessile lower heads are not sessile, they are actually immediately subtended by lateral branches bearing successive heads. This particular form of inflorescence, referred to as subdichasioid by

Adams (1956), is unknown in all but the present group among Old World members of the Vernoniaeae. For purposes of comparison, the superficially similar Neotropical *Vernonanthura* H. Rob. (1902) is the best choice. The African species studied here with divergent seriately cymose inflorescence branches differ from *Vernonanthura* by the mostly membranous rather than centrally coriaceous involucre bracts, having a narrow median ridge instead of a broad shield, and having irregularly denticulate rather than entire margins. Internally, the corolla lobes of the African material totally lack the marked longitudinal resinous cells that are evident in *Vernonanthura* and its closest relatives. The achenes are 5-costate rather than 8-10 costate. The raphids of the achene wall are narrowly rhomboid rather than subquadrate or shortly oblong. A final character of seemingly primary importance is in the sweeping hairs of the style. These hairs in the African species are almost totally restricted to the style branches. This is similar to other Old World Vernoniaeae and unlike the New World Vernoniaeae that have sweeping hairs clearly present on the upper style shaft below the branches. In this respect, the African group is like most other Old World Vernoniaeae that have sweeping hairs nearly or completely restricted to the style branches. Thus, in spite of the superficial similarity, the African and American entities are not here considered close relatives.

Regarding the generic placement of the African group studied here, a more recently described African genus, *Orbivestus* H. Rob. (1999), as typified by *Vernonia karaguensis* Oliv. & Hiern, shows the divergently cymose structure of the branches of the inflorescence that is characteristic of the present group. This characteristic was not appreciated at the time of the description of that African genus.

The relationship *Orbivestus* to other African Vernoniaeae is not certain. Recent efforts have shown that many of the Tropical African Vernoniaeae are individually distinctive, and their generic dispositions remain to be established. One of the species included here, *Vernonia leopoldii* Vatke, was placed in the genus *Hilliardiella* H. Rob. by Robinson (1999). That is now seen as a mistake. *Hilliardiella* is from farther south in Africa, while *V. leopoldii* and its relatives are mostly central African, especially Ethiopian and Eritrean. *Hilliardiella* also lacks the branching in the inflorescence from immediately below the older heads. It has only 3-4 series of involucre bracts rather than 5-7, its corollas have numerous T-shaped hairs distally, the anthers lack tails

at the bases of the thecae, while *Orbivestus* has well-developed tails, and the pappus bristles of *Hilliardiella* are not flattened on the outer surface as they are in *Orbivestus*.

Even more highly developed seriate cymes are known in one other African member of the Vernonieae that is not recently introduced, *Manyonia* H. Rob., also of Central Africa. In the latter case, the genus seems to have close relatives in tropical America, especially *Dipterocypsela* S.F. Blake (Robinson 1999) of Colombia.

Evidently, an African lineage of the Vernonieae has separately evolved seriately cymose heads that are immediately subtended by lateral branches bearing further heads. These are not directly related to the New World members of the tribe with similar inflorescences. Such inflorescences have also evolved in more remote members of the Asteraceae such as some species of *Clibadium* L. in the Heliantheae.

There is more uniformity in the form, texture and coloration of the involucre bracts in *Orbivestus* than in many of the other genera of the Vernonieae. The tips are more acute in many specimens of *O. karaguensis* under the name *Vernonia cistifolia* O. Hoffm. in Engl., and at least one specimen of *O. unionis* (Sch.Bip. ex Walp.) H. Rob. Other unifying characteristics are the area of the sweeping hairs extending downward slightly onto the area where the style branches join, the T-shaped hairs, and the erect, rather than recoiled, lobes of the corolla.

Orbivestus H. Rob., Proc. Biol. Soc. Wash. 112(1): 230. 1999. Type:

Vernonia karaguensis Oliv. & Hiern

Vernonia subg. *Orbisvestus* S.B. Jones, Rhodora 83: 60. 1981. Type:

Vernonia karaguensis Oliv. & Hiern

Subshrubs to small shrubs with erect stems from a woody base, not or sparsely branched between base and inflorescence; hairs T-shaped. Leaves alternate, usually decrescent upwardly, sessile or short petiolate, blades elliptical or ovate to oblanceolate, mostly 4-9 cm long, 2-5 cm wide, base short-obtuse to acuminate, margins scarcely repand - dentate, apex short-acute, upper surface with small spinules and few small hairs, lower surface paler, grayish with slender hairs and partially

sunken glandular dots, venation pinnate with up to 6 or 8 lateral veins each side, spreading at 45-60° angles. Inflorescences with leaves of main axis only somewhat to greatly reduced, with only minute bracteoles on branches. Inflorescence shape broadly corymbiform or cylindrical with rounded to flattened top, with lower heads appearing sessile as result of proliferation by immediately subtending branches, branches of inflorescence tomentose with T-shaped hairs. Heads broadly campanulate, 4-14 mm high and wide; involucre bracts mostly persistent, innermost somewhat deciduous, ca. 50-100 in 5-7 series, strongly gradate, 1-8 mm long, 1.0-1.5 mm wide, ovate to oblong, subacute and mucronate to apiculate at tip, innermost acute, tips appressed, margins membranous and irregularly denticulate distally, often reddish, with dark median keel extending to apex, scarcely thickened and greenish near keel, with numerous small T-shaped hairs except at margins. Receptacle epaleate, tuberculate. Florets 15- ca. 50 in a head; corollas purplish, narrowly funnel form, 4-8 mm long, with sparsely scattered glandular dots, tube slender, 2-3 mm long, throat 1.5-2.5 mm long, lobes 1.0-2.5 mm long, linear-lanceolate, erect, not recurving, sparsely glanduliferous to distinctly or minutely scabridulous outside, without longitudinal internal ducts filling lobe; anther thecae 1-2 mm long, without glandular dots, calcarate and with long tails at base, endothelial cells short, usually with 2-3 nodes on transverse walls; apical appendage 0.5-1.0 mm long, narrowly lanceolate, often sharply acute; style base with distinct expanded node; sweeping hairs on style branches and scarcely extending on to upper style shaft, slender and narrowly acute. Achenes 1-5-2.0 mm long when mature, 5-costate, with few to many setulae when young, often glabrous at maturity, often with numerous glandular dots on sides between costae, surface with numerous idioblasts that are not joined in series, with narrowly rhomboid raphids internally; carpopodium stopper-shaped to slightly turbinate, with many series of small thick-walled cells; inner pappus of 25-30 slender capillary bristles, rather flattened outside and barbellate on sides, tips only slightly narrowed, outer pappus of narrow scales 0.5-1.5 mm long. Pollen grains ca. 50 µm in diam in fluid, type A, sublophate, tricolporate, echinate, with perforated tectum continuous between colpi.

As presently known, the genus contains the following eleven species. *Vernonia homilantha* S. Moore and *V. undulata* Oliv. & Hiern,

placed in the genus by Robinson (1999) do not have the seriate-cymose condition now seen as characteristic of *Orbivestus*. In the case of *Orbivestus homantha* (S. Moore) H. Rob., the species does have the T-shaped hairs and the acute tips of the sweeping hairs and some of the overall aspect of *Orbivestus*, and the species is not at this time rejected from the genus. In the case of *Vernonia undulata*, the inflorescence is of a completely different, laxly branching form, and the species is excluded here. It should be noted that many specimens under the name *V. undulata* seem to belong to the still unplaced *V. biafrae* Oliv. & Hiern.

Recently added to the genus, but not seen in this study, are *Orbivestus albocinerascens* (C. Jeffrey) Isawumi, *O. bamendae* (C.D. Adams) Isawumi, and *O. blumeoides* (Hook. f.) Isawumi (Isawumi 2008). Also not seen in this study, and not included in the genus, is *Vernonia brachtrichoides* C. Jeffrey of Tanzania, which Jeffrey (1988) placed close to *V. karaguensis*, but which he distinguished by its larger heads with involucre bracts to 10 mm long, corollas 10.5 mm long and pappus bristles 7.5-8.0 mm long.

Key to the species of *Orbivestus* as constructed from limited material, previous keys, and descriptions.

- 1. Heads with involucre 4-5 mm high and wide.....2
- 1. Heads with involucre 7-1.5 mm high and wide.....5
- 2. Erect herbs.....*O. karaguensis*
- 2. Weakly to distinctly shrubby, scrambling plants, or small trees.....3
- 3. Leaf blades remotely dentate on margins; all heads appearing shortly pedunculate; involucre bracts rounded at tips....*O. homilanthus*
- 3. Leaf blades subentire to undulate or minutely denticulate on margins; many heads appearing sessile with subtending lateral innovations; involucre bracts with pointed to mucronate tips.4
- 4. Corollas white.....*O. albocinerascens*
- 4. Corollas purple, mauve, or blue.....*O. cinerascens*

- 5. Leaf blades densely tomentose on abaxial surface.....*O. leopodii*
- 5. Leaf blades with pubescence not totally covering green abaxial surface.....6
- 6. Leaf margins with distinct serrations.....7
- 6. Leaf margins subentire, undulate, minutely denticulate, or with small callus-mucronations.....8
- 7. Leaf blades oblanceolate.....*O. catumbensis*
- 7. Leaf blades ovate.....*O. unionis*
- 8. Leaf blades auriculate near base.....*O. bamendae*
- 8. Leaf blades not auriculate near base.....9
- 9. Leaf blades acuminate into petiolate base.....*O. turbinata*
- 9. Leaf blades subsessile.....10
- 10. Heads ca. 1.3 cm long.....*O. blumeoides*
- 10. Heads ca. 7-8 mm long.....*O. teitensis*

The species of *Orbivestus*

Orbivestus albocinerascens (C. Jeffrey) Isawumi, Comp. Newsl. 46: 36. 2009. *Vernonia albocinerascens* C. Jeffrey, Kew Bull. 43(2): 222. 1988.

Orbivestus bamendae (C.D. Adams) Isawumi, Comp. Newsl. 46: 36. 2008. *Vernonia bamendae* C.D. Adams, W. African Science Assoc. 3: 116. 1957.

Orbivestus blumeoides (Hook.f.) Isawumi, Comp. Newsl. 46: 35. 2008. *Vernonia blumeoides* Hook.f., J. Linn. Soc. Lond., Bot. 7: 198. 1864.

Orbivestus catumbensis (Hieron.) H. Rob., **comb. nov.** basionym: *Vernonia catumbensis* Hiern, Cat. Welw. Afr. Pl. 1: 524. 1898.

Orbivestus cinerascens (Sch.Bip. in Schweinf.) H. Rob., Proc. Biol. Soc. Wash. 112(1): 211. 1999. *Vernonia cinerascens* Sch.Bip. in Schweinf., Beitr. Fl. Aeth. 162. 1897.

Vernonia tephrodoides Chiov., Fl. Somal. 2: 255. 1932.

Orbivestus homilanthus (S. Moore) H. Rob., Proc. Biol. Soc. Wash. 112(1): 230. 1999. *Vernonia homilantha* S. Moore, J. Bot. 41: 138. 1903.

Vernonia sennii Chiov., Fl. Somal. 2: 256. 1932.

Orbivestus karaguensis (Oliv. & Hiern) H. Rob., Proc. Biol. Soc. Wash. 112(1): 231. 1999. *Vernonia karaguensis* Oliv. & Hiern, Trans. Linn. Soc. Lond. 29: 91. 1873.

Vernonia johannis O. Hoffm. in Engl., Pflanzw. Ost-Afr. C 405. 1895.
Type: Tanzania, Ugueno, *Volkens* 467 (B, destroyed).
Neotype: Ruanda Région du Mutara, envirens de Mimuli, réserve IRSAC, colline Bibale, 27/3/1959, *Troupin II.636* (US).

Vernonia cistifolia O. Hoffm. in Engl., Pflanzw. Ost-Afr. C 404. 1895.

Vernonia elliotii S. Moore, J. Linn. Soc. Bot. 35: 315. 1902.

Vernonia bothrioclinoides C.H. Wright, Bull. Misc. Inf. 1906: 106. 1906.

Vernonia porphyroplepis S. Moore, J. Bot. 54: 251. 1980.

Vernonia multiflora De Wild., Feddes Repert. 13: 208. 1914 (non Less.).

Vernonia pilgeriana Muschl., Bot. Jahrb. Syst. 46: 78. 1911. Type: Tanzania, Ngare Olmotony, *Uhling* 208 (B, destroyed).
Neotype: Ruanda Région du Mutara, envirens de Mimuli, réserve IRSAC, colline Bibale, 27/3/1959, *Troupin II.636* (US).

Vernonia campanea S. Moore, J. Bot. 54: 251. 1916.

Vernonia melanacrophylla Cufod., Nouv. Giorn. Bot. Ital., n.s. 50: 102. 1943.

Vernonia multiflora is added to the synonymy, and two synonyms whose types were destroyed in Berlin are neotypified to

firmly fix their identity as members of this species. The synonymy follows the provisional synonymy given by Jeffrey (1988) plus evidence from the limited descriptions. Some specimens under the name *V. cistifolia* seem unlike other members of *Orbivestus* in the fewer rows and long tips on the involucre bracts.

The species may be interpreted too broadly. Material in the herbarium under the name *Vernonia cistifolia* from Malawi seems distinctive, with denser inflorescences and often dense tomentum on the abaxial surfaces of the leaves. One of the existing names in the synonymy, such as *Vernonia bothrioclinoides* C.H. Wright from Malawi, may represent this entity.

***Orbivestus leopoldii* (Sch.Bip. ex Walp.) H. Rob., comb. nov.**

Basionym: *Cyanopis leopoldii*(i) Sch.Bip. ex Walp., Repert. Bot. Syst. 2: 949. 1843. *Vernonia leopoldii* (Sch.Bip. ex Walp.) Vatke, Linnaea 39: 478. 1875. *Hilliardiella leopoldii* (Sch.Bip. ex Walp.) H. Rob., Proc. Biol. Soc. Wash. 112(1): 230. 1999.

Cyanopis hypoleuca Sch.Bip. ex Walp., Repert. Bot. Syst. (Walpers) 6: 98. 1846, not *Vernonia hypoleuca* DC.

Vernonia bipontinii Vatke, Linnaea 39: 478. 1875.

The species shows the weakest development of seriate cymes of any of those here added to the genus, but such branching is present, and other characters and geography all fit with *Orbivestus*.

***Orbivestus teitensis* (O. Hoffm. in Engl.) H. Rob., comb. nov.**

Basionym: *Vernonia teitensis* O. Hoffm. in Engl., Pflanzenw. Ost-Afr. C: 404 (1895). Type: Kenya, Teita, *Hildebrandt 2466a* (B, destroyed); Neotype: Kenya: Muthaiga, near Nairobi, alt. 1700 m, June 28- July 4 1927, *Piemeisel & Kephart 11* (US).

The species is presently known from Congo, Kenya, and Uganda in Central Africa as indicated by the three specimens cited below. Among the herbaria possibly having duplicates of *Piemeisel & Kephart* material are A, BM, MO, and NY.

Repeated attempts to key three specimens labeled as *Vernonia* from Kenya, Congo and Uganda in the treatment of *Vernonia* in East Tropical Africa (Jeffrey 1988) have failed. However, that same

publication provided a probable answer to the problem in a list of taxa insufficiently known. The description of *Vernonia teitensis* Hoffmann (Engler 1895) from Kenya, as far as it went, matched the unidentified material perfectly. The description as given by Hoffmann (Engler 1895) was, "*V. teitensis* O. Hoffm. n. sp.; suffruticosa; ramis junioribus villosis; foliis ellipticis breviter petiolatis vel subsessilibus repando-dentatis plerumque obtusis, basi angustatis, supra scabris, subtus puberulis et glanduloso-punctatis; capitulis parvulis 20 floris corymbosis; involucri late campanulati bracteis appressis acutis; acheniis 5 costatis subglabris." The Hoffmann name apparently has not been associated with any more recent collections until now. The original type was cited as from Kenya: Teita, *Hildebrandt 2466a* (deposited at Berlin). The type material in Berlin was evidently destroyed during WWII, but the name has a potential priority dating from 1895. Thus, in order to avoid any future confusion, the identity of the species is fixed here by neotypification using one of the specimens in the U.S. National Herbarium.

The three available specimens are as follows: KENYA: Muthaiga, near Nairobi, alt. 1700 m, June 28-July 4, 1927, *R.L. Piemeisel & I.W. Kephart 11* (US); BELGIAN CONGO: Foothills of mountains west of Katana, Lake Kivu, 6300 ft. disturbed vegetation at roadside, on top of bank; 6/7/59. *1959 Cambridge Congo Expedition 29* (US), woody stem, purple flowers very conspicuous, visited by bees; UGANDA PROTECTORATE: Ilipayo, grass bank, flower purplish, March 1914, *R. Dümmer 207* (US). The specimen chosen here as Neotype is the one from Kenya where the original type was collected, *Piemeisel & Kephart 11*. *Piemeisel & Kephart 11* (neotype US). It remains possible that an older name exists for this reasonably widespread central African species, but it seems unlikely since the present concept dates from 1895. In any case, the conclusions in this study are based on the preceding neotypification.

Orbivestus turbinata (Oliv. & Hiern) H. Rob., **comb. nov.** Basionym: *Vernonia turbinata* Oliver & Hiern ex Oliver, Trans. Linn. Soc. 29: 90, t. 56. F. B. 1873.

Orbivestus unionis (Sch.Bip. ex Walp.) H. Rob., **comb. nov.** Basionym: *Vernonia unionis* Sch.Bip. ex Walp., Repert. 2: 345. 1843.

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Figure 1. *Orbivestus teitensis* (O. Hoffm.) H. Rob. Neotype of *Vernonia teitensis* Hoffm. in Engl., Piemeisel & Kephart 11 (US)

NOMENCLATRURAL CHANGES IN THE BRYACEAE (BRYOPSIDA) FOR NORTH AMERICA III.

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ABSTRACT

The family *Roelliaceae* is newly described for the western North American monotypic endemic *Roellia roellii*. The new section *Gemmabryum* section *Tuberibryum* is described and typified by *Gemmabryum violaceum*. *Bryum* section *Cladodium* is transferred to *Ptychostomum*, and *Bryum* section *Caespitibryum* is transferred to *Gemmabryum*. Nine species are transferred to the genera *Gemmabryum*, *Leptostomopsis* and *Plagiobryoides* for the Flora of North America. *Phytologia* 91(3): 494-500 (December, 2009).

KEY WORDS: mosses, North America, Bryaceae, Roelliaceae

This paper represents the final installment of nomenclatural changes in the moss family Bryaceae for the Bryophyte Flora of North America (BFNA) project. New genera and combinations were described in the previous two papers (Spence 2005; Spence 2007) and in Spence and Ramsay (2005). Since the publication of the last installment, new species have been documented from the BFNA region, and the classification of the family has been finalized, necessitating new sectional names and transfers. In addition, due to its unusual morphology and complex peristome, the enigmatic western North American endemic *Roellia roellii* (Brotherus in Röhl) Andrews *ex* Crum is placed in its own family.

Roellia Kindberg, 1897

Roellia roellii has had a long confused history since it was first described. Brotherus originally described it as *Mnium roellii*, as it is morphologically similar to members of the Mniaceae. Following this,

E.G. Britton moved it to *Bryum* as *B. lucidum*. However, this name was already taken by another earlier species, so Holzingger described it as *Bryum sandbergii* in 1895. Other names the species has been given include *Mnium simplex*, *Roellia simplex*, and *Roellia lucida*, all Kindberg names. The oldest basionym is *Mnium roellii* Brotherus & Röhl. Crum transferred the species to *Roellia* Kindberg in 1967 (Crum 1967). The complete synonymy is found below.

Mnium roellii Brotherus in Röhl, Bot. Centralbl. 44: 420. 1890.; *Roellia roellii* (Brotherus in Röhl) Andrews ex H. Crum, The Bryol. 70: 107. 1967.

Bryum lucidum Britton, Bull. Torrey Bot. Club 16: 34. 114. f. 1--17. 1891, hom. Illeg.; *Mnium lucidum* Brotherus, Hedwigia 32: 293.

1893; *Roellia lucida* Kindberg, Eur. N. Amer. Bryin. 2: 345. 1897.

Bryum simplex Kindberg in Macoun, Cat. Canad. Pl., Musci 133. 1892, hom. Illeg.; *Mnium simplex* Kindberg, Rev. Bryol 23: 22. 1896;

Roellia simplex Kindberg, Eur. N. Amer. Bryin. 2: 346. 1897;

Rhodobryum simplex Paris, Index. Bryol. 1121. 1898.

Bryum sandbergii Holzingger, Contr. U.S. Natl. Herb. 3:271. 1895;

Roellia sandbergii (Holzingger) Paris, Index Bryol. (ed. 2) 4: 223.1905.

The species is unusual in several respects. First, although superficially similar to *Rhodobryum*, it lacks the stolons of that genus, and also does not produce micronemata on the stem. The leaves are large, pale green, and the surface is finely wrinkled. The laminal cells are extremely large, but otherwise conform to the *Rhodobryum*-type areolation. The most unusual features are those of the peristome (Shaw 1985), which has a unique formula of 4:2:10–14 and up to 6 nodose cilia. Because of its morphology, intermediate between the Bryaceae and Mniaceae, and several unique characters of both the gametophyte and sporophyte, it is best placed in its own family, near the Mniaceae. Vitt (1993) has mapped the distribution of the species in North America. It is restricted to cool or cold temperate oceanic subalpine and low alpine environments, where it occurs on litter under shrubs and trees (Spence 1986).

Roelliaceae J.R. Spence **fam. nov.**

Plantae ad species Mniacearum accedentes; caulibus rosulatis, micronematibus nullis, macronematibus sparsis, foliis obovatis, tenuiter rugosis, marginibus distalibus serratis, cellulis laminae magnis, $90-150 \times 30-50 \mu\text{m}$ limbidio nullo, costa in sectione transversali strato stereidarum reducto vel nullo, structuris asexualibus reproductivis nullis; dioicae; capsulis cyclindricis, peristomio perfecto, in formulam 4:2:10-14 disposito, ciliis nodosis 3-6, sporis parvis 10-15 μm .

Plants with affinities to the Mniaceae; stems rosulate, micronemata lacking, macronemata sparse; leaves obovate, finely rugose, distal margins serrate, laminal cells large, $90-150 \times 30-50 \mu\text{m}$, limbidium lacking, costa cross-section with reduced or absent stereid band, asexual reproductive structures lacking; dioicous; capsules cylindrical, peristome perfect, formula 4:2:10-14, with 3-6 nodose cilia, spores small, 10-15 μm .

Type genus: *Roellia* Kindberg, Gen. Eur. & North Amer. Bryin. 37. 1897.

Gemmabryum J.R. Spence & H.P. Ramsay, 2005

The group of tuber-bearing *Gemmabryum* species, informally known as the *Erythrocarpa sensu* Crundwell and Nyholm (1964), requires a valid sectional name. All sectional names used for this group of species are apparently invalid.

Gemmabryum section *Tuberibryum* J.R. Spence, **sect. nov.**

Caules aequaliter foliati, foliis laxe positis, in statu sicco leviter tortis, tuberibus rhizoidalibus vulgaribus, sphaericis vel pyriformibus vel raro stellatis, (40-) 60-200 (-250) μm in latitudine maxima, cellulis planis vel tumescentibus, dioicae vel raro synoicae, capsulis pyriformibus vel cyclindicis, peristomio maximam partem perfecto, sporis parvis 10-20 μm .

Stems evenly foliate, leaves loosely set, slightly twisted when dry; rhizoidal tubers common, spherical to pyriform or rarely stellate, (40–) 60–200 (–250) μm in widest dimension, cells flat to bulging; dioicous or rarely synoicous; capsules pyriform to cylindrical, peristome mostly perfect, spores small, 10–20 μm .

Type species: *Gemmabryum violaceum* (Crundwell & Nyholm) J.R. Spence.

The discovery and verification of rhizoidal tubers in *Bryum caespiticium* (Zolotov 2002) combined with the elongate distal laminal cells, shorter proximal cells and lack of a leaf limbidium, suggest that the species is better placed in *Gemmabryum* than in *Ptychostomum*, where I originally placed it and its allies. Tubers are unknown in *Ptychostomum*. There are 5–6 species in the section typified by *B. caespiticium*, two others of which also occur in North America. The section is transferred to *Gemmabryum* along with the three species found in North America.

Gemmabryum section *Caespitibryum* (Podpera) J.R. Spence, **comb. nov.** Basionym: *Bryum* subsect. *Caespitibryum* Podp., Rozpr. České Akad. Věd, TY. 2, Vědy Mat. PYír. 10(2): 52. 1901; *Bryum* section *Caespitibryum* (Podpera) J.J. Amann, Fl. Mouss. Suisse 2: 226. 1918

Gemmabryum badium (Bruch ex Bridel) J.R. Spence, **comb. nov.** Basionym: *Bryum caespiticium* var. *badium* Bruch ex Bridel, Bryol. Univ. 1: 850. 1827.

Gemmabryum caespiticium (Hedwig) J.R. Spence, **comb. nov.** Basionym: *Bryum caespiticium* Hedwig, Sp. Musc. Frond. 1801.

Gemmabryum kunzei (Hornschuch) J.R. Spence, **comb. nov.** Basionym: *Bryum kunzei* Hornschuch, Flora 2(1): 90. 1819.

***Ptychostomum* Hornschuch, 1822**

Ptychostomum includes two major groups, the type subgenus and *Cladodium*, which is here transferred to *Ptychostomum* from *Bryum*.

Ptychostomum* subgenus *Cladodium* (Bridel) J.R. Spence, **comb. nov.*
Basionym: *Cladodium* Bridel, Bryol. Univ. 1: 620. 1826.

***Leptostomopsis* (Müll. Hal.) J.R. Spence & H.P. Ramsay, 2005.**

The recent discovery of *Brachymenium niveum* Bescherelle in the Bryophyte Flora of North America region, which will be documented elsewhere (Spence in prep.), requires a transfer to *Leptostomopsis* to which it belongs.

Leptostomopsis nivea* (Bescherelle) J.R. Spence, **comb. nov.*
Basionym: *Brachymenium niveum* Bescherelle, J. Bot. (Morot) 15: 383. 1901.

***Plagiobryoides* J.R. Spence, 2005**

Recent field work and herbarium studies have documented the presence of several species in North America that are morphologically close to *Plagiobryoides incrassatolimbata* (Cardot) J.R. Spence. *Plagiobryoides* is characterized by very large and lax laminal cells and capsules that often have a long well-developed hypophysis. Although the type, *P. incrassatolimbata*, has a unique multi-stratose border, it is otherwise very similar to the other species listed below. Recently, I have also found that some species produce extremely large rhizoidal tubers, with diameters of nearly 0.5 mm. The following five species are transferred to the genus. Originally, I had transferred the widespread pantropical *Bryum cellulare* to *Plagiobryum* for the Flora of Australia, as it is closer to that genus than to *Bryum*. However, it is better placed in *Plagiobryoides*, emphasizing the significant sporophytic differences between that genus and *Plagiobryum*.

Plagiobryoides brachyneura (Kindberg) J.R. Spence, **comb. nov.** Basionym: *Bryum brachyneuron* Kindberg, Ottawa Naturalist 5: 179. 1892.

Plagiobryoides cellularis (Hooker) J.R. Spence, **comb. nov.** Basionym: *Bryum cellulare* Hooker, Sp. Musc. Frond., Suppl. 3: 1(1): 214: a. 1827.

Plagiobryoides limbata (Müll. Hal.) J.R. Spence, **comb. nov.** Basionym: *Bryum limbatum* Müll. Hal., Syn. Musc. Frond. 2: 573. 1851.

Plagiobryoides renauldii (Röll ex Renauld & Cardot) J.R. Spence, **comb. nov.** Basionym: *Bryum renauldii* Röll ex Renauld & Cardot, Bull. Soc. Roy. Bot. Belgique 38(1): 13. 1900.

Plagiobryoides vinosula (Cardot) J.R. Spence, **comb. nov.** Basionym: *Brachymenium vinosulum* Cardot, Rev. Bryol. 38: 6. 1911.

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TAXONOMIC NOTES ON ACAULESCENT *OXALIS* (OXALIDACEAE) IN THE UNITED STATES

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ABSTRACT

A key to species and typification summaries with descriptions, notes on variation, and geography are presented for 10 acaulescent *Oxalis* species occurring in the USA, both native and naturalized: *O. articulata*, *O. caerulea*, *O. debilis*, *O. decaphylla*, *O. drummondii*, *O. intermedia*, *O. latifolia*, *O. metcalfei*, *O. triangularis*, and *O. violacea*. *Oxalis metcalfei* (previously identified in the USA mostly as *O. alpina*) occurs in Arizona, Colorado, New Mexico, and Texas. *Oxalis latifolia* occurs in Arizona, New Mexico, and Texas, at the northern extremity of its range. *Oxalis intermedia*, native to the West Indies, has previously been known to be naturalized in the USA in Florida and is reported here from Louisiana and Texas. *Oxalis debilis* (including *O. corymbosa*) occurs across seven coastal states of the southeastern USA and is reported here for California by a voucher and for Washington by a sight record. *Phytologia* 91(3): 501-526 (December, 2009).

KEY WORDS: *Oxalis* sect. *Ionoxalis*, *Oxalis latifolia*, *Oxalis articulata*, *Oxalis debilis*, *Oxalis intermedia*, taxonomy, distribution

Oxalis sect. *Ionoxalis* (Small) R. Knuth includes bulb-producing, acaulescent species with white to blue, purple, or pink flowers. The North American representatives were monographed by Denton (1973), who provided useful insights into a taxonomically difficult group, but problems have remained and identifications have been inconsistent. In Arizona and New Mexico, particularly, where Denton recognized the presence of *O. alpina*, *O. latifolia*, *O. drummondii*, "aff. *O. drummondii*," and *O. violacea*, the present study identifies the same plants as *O. metcalfei* and *O. latifolia*. *Oxalis caerulea* has been a poorly understood and apparently under-collected

species. In the southeastern USA, adventive species of sect. *Ionoxalis* from subtropical and tropical regions are ambiguous in some points of identity and nomenclature. The present study attempts to clarify species identities, nomenclature, and geographic distribution of a number of the North American taxa of sect. *Ionoxalis*. The acaulescent *O. articulata* also is included in the account here, although a member of sect. *Articulatae* R. Kunth.

In the present study, all citations of localities in the USA and Mexico are from specimens examined, unless otherwise specifically noted. Collections were studied from ARIZ, ASU, BRIT-SMU-VDB, GH, MO, NLU, and TEX-LL.

KEY TO SPECIES

- 1. Leaflets mostly 4–11, rarely 3.
 - 2. Leaflets mostly 4(–5), obtriangular to obovate, lobed 1/5–1/2 length, 5–22 mm long; bulb scales (3–)5–7)-nerved 1. **Oxalis caerulea**
 - 2. Leaflets mostly (4–)5–11, mostly narrowly oblong-ob lanceolate to narrowly oblong or linear, lobed (1/5–)1/2–2/3(–9/10) length, (10–)12–38(–72) mm long; bulb scales 9–15+)-nerved 2. **Oxalis decaphylla**
- 1. Leaflets 3.
 - 3. Leaflets with oxalate dots around the margins or evenly over the lamina, or both.
 - 4. Plants arising from a thick, woody, irregularly nodulate-segmented rhizome often with persistent, thickened, and lignescent petiole bases; flowers 3–12 in umbelliform cymes, less commonly in irregular cymes.....9. **Oxalis articulata**
 - 4. Plants arising from a dense cluster of sessile bulblets; flowers (3–)8–14(–28) in irregular cymes 7. **Oxalis debilis**
 - 3. Leaflets without oxalate dots or tubercles, or with marginal tubercles only on both sides of the notch.
 - 5. Plants arising from scale-clad rhizomes; leaflets purple

- 9. **Oxalis triangularis**
5. Plants arising from bulbs or bulbs and bulblets, without scale-clad rhizomes; leaflets mostly green.
6. Leaflets obtriangular to broadly obtriangular, lobes apically nearly flat; plants arising from a dense cluster of sessile bulblets; southeastern USA (expected in California)
- 8. **Oxalis intermedia**
6. Leaflets obtriangular to obcordate, lobes apically rounded to convex; plants arising from a single bulb or a dense cluster of sessile bulblets; eastern to southwestern USA.
7. Plants arising from a dense cluster of sessile bulblets; bulb scales 3-nerved; southwestern USA
- 3. **Oxalis metcalfei**
7. Plants arising from a single bulb, rarely producing bulblets at the ends of slender rhizomes; bulb scales 3-nerved or (5-)7-9(-11)-nerved; eastern USA to southwestern USA.
8. Bulb scales (5-)7-9(-11)-nerved; southwestern USA
- 4. **Oxalis latifolia**
8. Bulb scales 3-nerved; primarily eastern USA.
9. Leaflets without oxalate deposits, obtriangular to obcordate, (6-)14-34 mm, lobes divergent, tubercles of sepal apices 2 or 3-6, linear and prominently thickened, apically confluent...
- 5. **Oxalis drummondii**
9. Leaflets consistently with oxalate deposits at the base of the notch, rounded-obcordate to obreniform, (5-)8-15(-20) mm, lobes geminate; tubercles of sepal apices 2, linear and narrow, apically confluent
- 6. **Oxalis violacea**

1. ***Oxalis caerulea*** (Small) R. Knuth, Notizbl. Bot. Gart. Berlin-Dahlem 7: 316. 1919. *Ionoxalis caerulea* Small, N. Amer. Fl. 25: 33. 1907. **TYPE:** USA. New Mexico. Lincoln Co.: Gray, ca. 6000 ft, 7 Jun 1898, *J. Skehan 112* (holotype: NY-digital image!; isotypes: GH!, MO!, NY-digital image!, US-digital image!). The NY and US sheets were annotated by Lourteig in 1988 and 1989 as *O. lunulata* Zucc.

Plants perennial, acaulescent, glabrous, arising from single, brownish bulbs; bulb scales (3-)5-7-nerved. **Leaves** all basal; leaflets (3-)4(-5), obtriangular to obcordate, 5-22 mm, lobed 1/5-1/2 length, lobes apically rounded, green above, slightly paler green to purplish beneath, oxalate deposits absent or as a few punctate tubercles near the leaflet lobe apices, petioles 3-10(-13) cm. **Flowers** (1-)2-7 in umbelliform cymes, distylous; scapes 6-12(-15) cm; sepal apices with a pair of linear, orange tubercles; corollas 8-10 mm; petals red to pinkish-lavender. **Capsules** ellipsoid, 3.5-6 mm. $2n$ = unknown.

Flowering Jun-Sep. Stream beds, creek sides, meadows, pinyon-juniper, pine-oak-juniper, pine-aspen; (1800-)2000-2600 m. Native to Arizona (Apache, Coconino, Graham, Navajo, Pima, and Yavapai cos.), Colorado (Fremont Co.), New Mexico (Catron, Colfax, Grant, Lincoln, San Miguel, and Valencia cos.; Mexico (Chihuahua, Durango, Sonora).

Among the bulb-forming species of the southwestern USA, *Oxalis caerulea* has the smallest plants and leaves. If 4 obtriangular to obcordate leaflets are observed, the identity as *O. caerulea* is fairly secure, although 3 and 4 leaflets may sometimes be produced on a single plant. *Oxalis decaphylla* also produces more than 3 leaflets, but if only 4 leaflets, they are larger and differently shaped and the plants generally grow at higher elevations than *O. caerulea*. Denton's key to species (1973, p. 491) emphasized the relative extension of flanges at petiole bases in separating *O. caerulea* and *O. lunulata* Zucc. from other species — this feature, however, is difficult to interpret and the flanges often are damaged or apparently missing.

Type specimens of *Oxalis caerulea* at NY and US were annotated by Lourteig in 1988 and 1989 as *O. lunulata*, and she

included *O. caerulea* as a synonym of *O. lunulata* (Lourteig 2000). Denton (1973, p. 575) noted that "The closest ally to *O. lunulata* is *O. caerulea* which occurs in northern Mexico and southwestern USA. *Oxalis caerulea* is intermediate in morphology between *O. lunulata* and *O. divergens* but is not sympatric with either of those two species." Denton (Fig. 6) mapped *O. caerulea* in Mexico in Durango and Chihuahua, *O. lunulata* from central Zacatecas southward to Guatemala.

Sivinski (2005) noted that *Oxalis caerulea* "is either rare in NM or very difficult to accurately identify." The small size of the plants, perhaps missed in surveys and general collecting, might also contribute to the apparent paucity of the species. Because this species has been poorly known, the following collections are cited, all examined in the current study.

ARIZONA. Apache Co.: ca. 5.5 road mi N of Nutrioso and 1.3 mi N on Apache Co. Rd 2116, pinyon-juniper-ponderosa, at hilltop, 7200 ft, 9 Aug 1991, *Christy 824* (ASU). **Coconino Co.:** Coconino Natl. Forest, Upper West Fork Canyon of Oak Creek, ca 10 mi NNE of Sedona, short ways down Fernow Draw from Forest Service Rd 231, first confluence, within northern section of Red Rock Secret Mt. Wilderness, open field, 6500 ft, 2 Sep 2001, *Gilbert 830* (ASU); Coconino Natl. Forest, Upper West Fork Canyon of Oak Creek, canyon mouth located 15 km N of Sedona, ca. 0.5 mi down Casner Cabin Draw from wilderness boundary, seasonal stream bed, 6600 ft, 10 Aug 2002, *Gilbert 948* (ASU); Flagstaff, 7000 ft, 26 Sep 1923, *Hanson 729* (MO); Flagstaff, 10 Aug 1910, *Irish 10155* (ARIZ); Houston Draw, open meadow in coniferous forest, 2194 m, 3 Aug 1989, *Knight 369* (ASU); Flagstaff, 6900 ft, 5 Aug 1936, *Sneddan s.n.* (ARIZ); Flagstaff, 12 Aug 1907, *Thornber s.n.* (ARIZ); Flagstaff, 20 Jul 1930, *Thornber s.n.* (ARIZ, SMU); Flagstaff, near Museum, 7100 ft, 11 Aug 1935, *Whiting 756/1466* (ARIZ). **Graham Co.:** Coronado Natl. Forest, Soda Water Spring Canyon, Madrean oak woodland along creek, *Q. hypoleucoides*, *Q. emoryi*, *Pinus cembroides*, *Juniperus deppeana*, *Arctostaphylos pungens*, NE aspect, 5900 ft, 2 Aug 1999, *Buegge 1005* (ASU). **Navajo Co.:** White Mt. Apache Reservation, ca. 12 mi E of Seven Mile School at Crooked Creek, pine-aspen, boggy area along stream, 27 Jul 1975, *Lane 1610* (ASU). **Pima Co.:** Rincon Mts., 7900 ft, 20 Sep

1909, *Blumer* 3381 (MO). **Yavapai Co.:** near Prescott, 8 Aug 1926, *Peebles et al.* 2657 (ARIZ). **COLORADO. Fremont Co.:** Texas Cr., Aug 1879, *Brandegee* 875 (MO). **NEW MEXICO. Catron Co.:** 7 mi W of Red Hill, ponderosa pine forest, 7000 ft, 12 Aug 1964, Kral 21844 (VDB). **San Miguel Co.:** near Pecos, 6700 ft, 19 Aug 1908, *Standley* 5099 (MO). **Valencia Co.:** no other locality information, 22 Aug 1939, *Vestal* 94 (GH). **County unknown:** 1847, *Fendler* 91 (GH-3 sheets, MO). Denton (1973) also cited the following collections of typical *O. caerulea* from New Mexico: **Catron Co.:** near Luna, *Eggleston* 20254 (NY, US). **Colfax Co.:** vicinity of Ute Park, *Standley* 13754 (US). Emshwiller et al. (in press) record McKinley Co., N.M., in the range of the species.

Denton (1973, pp. 507–508) identified and cited some collections as “aff. *O. caerulea*,” “a subtle variant which is a putative hybrid between *O. drummondii* and *O. caerulea*. The leaves have 3–4 leaflets which may be abnormally trilobed. Practically all of the pollen was shriveled, only 1–2 percent was normally shaped and accepted the stain in an aniline blue pollen preparation.” She cited these: **NEW MEXICO. Colfax Co.:** vic. of Ute Park, 2 Sep 1916, *Standley* 14255 (US). **Grant Co.:** Santa Rita del Cobre, copper mines, Aug 1851, *Wright* 908 (GH, NY). **San Miguel Co.:** near Pecos, 19 Aug 1908, *Standley* 5099 (NY, US). Some of the collections examined in the present study from around Flagstaff (Coconino Co., Arizona) and elsewhere apparently are similar in leaf morphology to these “variants,” but neither the present study nor Denton’s has recognized the occurrence of *O. drummondii* in New Mexico or northern Arizona, and it is unlikely that genes of that species are involved. The pollen inviability and putatively abnormal leaf morphology probably are related to something other than hybridization.

2. *Oxalis decaphylla* Kunth in A. Humboldt et al., *Nov. Gen. Sp.* 5(qto.): 185. 1822. **TYPE:** MEXICO. “Crescit in planitie Mexicana, prope rupem El Peñon, alt. 1170 hex.,” *Bonpland* 4170 (holotype: P; isotype: P). Fide Denton (1973).

Ionoxalis grayi Rose, *Contr. U.S. Natl. Herb.* 10: 112. 1906. *Oxalis grayi* (Rose) R. Knuth, *Notizbl. Bot. Gart. Berlin-Dahlem* 7: 317. 1919 (non Tidestrom 1923). **Type:** USA. New Mexico. No other

locality data, 1851, *C. Wright* 909 (holotype: US, digital image!, fragment NY; isotype: GH!).

Plants perennial, acaulescent, rarely without leaves, glabrous, arising from brownish, heavily fibrous bulbs; bulb scales 9–15+ nerved. **Leaves** all basal; leaflets (3–)5–11, mostly narrowly oblong-ob lanceolate to narrowly oblong or linear, (10–)12–38(–72) mm, lobed (1/6–)1/2–2/3(–9/10) length, lobes apically subacute, bright green above, slightly paler green to purplish beneath, oxalate deposits absent, petioles 7–32(–46) cm. **Flowers** (2–)6–11(–15) in umbelliform cymes, distylous; scapes 7–35 cm; sepal apices with thick, linear, orange tubercles; corollas (7–)9–17(–22) mm, rose-purple or lavender to pink, rarely white. **Capsules** ellipsoid, 3–11 mm. $2n = 28, 56$ (counts from Mexico; Weller & Denton 1976).

Flowering Jun–Aug. Sycamore-walnut, oak, pine-oak, ponderosa pine, pine-spruce-aspen, spruce-fir, canyons, meadows, seeps, streamsides; (1700–)2200–3000(–3200) m. Native to Arizona (Apache, Cochise, Coconino, Gila, Greenlee, Navajo, Pima, Santa Cruz, and Yavapai cos.), New Mexico (Catron Co.), and Mexico (south to southwestern and central states).

Leaflets of *Oxalis decaphylla* are heteroblastic (Denton 1973), changing form from juvenile to mature stages of a single plant, and also variable in adult form, especially in width and number of lobes.

3. *Oxalis metcalfei* (Small) R. Knuth, Notizbl. Bot. Gart. Berlin-Dahlem 7: 314. 1919. *Ionoxalis metcalfei* Small in N.L. Britton et al., N. Amer. Fl. 25: 39. 1907. **TYPE:** USA. New Mexico. [Socorro Co.]: Mogollon Mountains, Mogollon Creek, ca. 7500 ft., 23 Jul 1903, *O.B. Metcalfe* 299 (holotype: NY-digital image!; isotypes: ARIZ!, GH!, MO!, US-digital image!).

Ionoxalis monticola Small, N. Amer. Fl. 25: 42. 1907 [non Arechav. 1900]. *Oxalis neomexicana* R. Knuth [nom. nov.], Notizbl. Bot. Gart. Berlin-Dahlem 7: 315. 1919. **TYPE:** USA. New Mexico. Grant Co.: in and around the S end of the Black Range, Iron Creek, hillside, ca. 7800 ft, 12 Aug 1904, *O.B. Metcalfe* 1220 (holotype: NY, digital image!; isotypes: GH!, MO!, digital image!, US, digital image!).

Oxalis bulbosa A. Nelson, Amer. J. Bot. 23: 269. 1936. **TYPE:** USA. New Mexico. [Sandoval Co.]: on the gravelly soils of creek banks, the Univ. Camp, Jemez Springs, [silt soils adjacent to the Jemez River], 20 Aug 1931, A. Nelson 11609 (holotype: RM, digital image!).

Plants perennial, acaulescent, glabrous, arising from a primary bulb (sometimes not evident) 5–10 mm long and a cluster of ovoid bulblets 3–4 mm long; bulb scales 3-nerved. **Leaves** all basal, leaflets 3, obtriangular-obcordate, 11–25 mm, lobed 1/6–1/3 length, lobes rounded to shallowly convex, green on both surfaces, oxalate deposits in a thin, marginal band 0.5–1.5 mm long on both sides of the notch base, sometimes evident on one surface but not the other, rarely apparently absent; petioles 7–15 cm. **Flowers** 3–7 in umbelliform cymes, tristylous and distylous; scapes 7–22 cm, peduncles 15–25 cm, pedicel 20–30 mm; sepal apices with a pair of orange, narrow-elongate, non-confluent tubercles; corollas (9–)12–16 mm, petals purplish to lavender or pink. **Capsules** cylindric, 6 mm. $2n = 28$ in Arizona and New Mexico, $2n = 42$ only in New Mexico (Weller & Denton 1976).

Flowering Jun–)Jul–Sep(–Oct). Stream sides, wet meadows, canyon bottoms, talus, rocky banks, crevices, juniper-chaparral, *Cercocarpus*, pine, yellow pine-doug fir-oak, douglas fir-aspen, pine-white fir-douglas fir, spruce-fir, spruce; 1800–3100(–3400) m. Native to Arizona (Apache, Cochise, Coconino, Gila, Graham, Greenlee, Pima, Santa Cruz, and Yavapai cos.), Colorado (La Plata Co.; also Archeluta, Hinsdale, and Mineral cos., fide Emschwiller et al. in press), New Mexico (Bernalillo, Catron, Grant, Otero, Sandoval, Sierra, Socorro, and Taos cos.; also Colfax Co., fide Welle & Denton 1976), Texas (Jeff Davis Co.), and Mexico (Chihuahua, Durango, Sonora, Zacatecas).

Oxalis metcalfei is common in Arizona and New Mexico but in Texas is known from only two collections: Jeff Davis Co.: Davis Mts., N slope and summit of Mt. Livermore, moist soil of ledges, 29 Jun 1946, Cory 13523 (SMU); Mt. Livermore, 22 Sep 1934, Hinckley s.n. (TEX).

In Nelson's description of *Oxalis bulbosa* (1936), he described the habit: "bulblets 50 or more crowded in a subspherical mass 12–20

mm in diameter and largely concealing the crown scales; bulblets small, easily detached at maturity, ovoid to subspherical, 2–4 mm in diameter, very compact.” In the southwestern USA, the presence of bulblets on a montane *Oxalis* provides an unequivocal identification as *O. metcalfei*, in distinction to *O. latifolia*, the only other 3-foliolate species in the area with a similar aspect. If only the primary bulb (or a single small bulb/bulblet) is present, the bulb scales of *O. metcalfei* are 3-nerved (vs. 5–7(–11)-nerved in *O. latifolia*). If the specimen does not include below-ground parts, observation of oxalate deposits on the leaves can confirm the identification as *O. metcalfei* — the narrow oxalate deposits sometimes are difficult to discern or perhaps even absent, but they are never produced on leaves of *O. latifolia*. Specimens from ARIZ annotated as *O. metcalfei* and *O. latifolia* are shown in the database at ARIZ Herbarium (2009); those from ASU will be shown on SEINET (2009).

Oxalis metcalfei has mostly been identified as *O. alpina* (Rose) Rose ex R. Knuth (e.g., Denton 1973; numerous publications by Weller and collaborators; Ornduff & Denton 1998; Emshwiller et al. in press). The type of *O. alpina* is from south-central Mexico (see citation below), and I have not seen evidence that the species reaches northwestern or northeastern Mexico. Denton’s map (1973, Fig. 5) shows a wide hiatus in distribution between her records in the southwestern USA and northern Chihuahua and Sonora (*O. metcalfei*) and those mostly in central and southwestern Mexico (*O. alpina* sensu stricto).

The similarity of *Oxalis metcalfei* to *O. alpina* is confirmed in the present study, but morphological differences are shown in the following contrast.

- a. Leaflets with dot-like oxalate deposits scattered through lamina, concentrated near margins, or as continuous, filiform marginal bands around the lobe apices, sometimes apparently absent; corollas mostly white.....***Oxalis alpina***
- a. Leaflets with oxalate deposits as a filiform, marginal band 0.5–1.5 mm long on both sides of the notch base, rarely apparently absent; corollas mostly purplish to lavender or pink.....***Oxalis metcalfei***

The significance of these features in recognizing *O. alpina* was emphasized by Denton (1973, p. 503), who noted that *O. jacquiniana* Kunth is usually distinguished from *O. alpina* by the lack of oxalate deposits on the leaflets and that "in western Mexico, a few populations of *O. galeottii* [Turcz.] resemble *O. alpina* by having white flowers ...". Denton's identification of some collections of *O. metcalfei* in Arizona as *O. violacea* perhaps reflected their similarity in producing oxalate deposits at the base of the leaflet notches. In view of their morphological distinction and their geographical separation, *O. metcalfei* and *O. alpina* are justifiably treated as distinct species.

Weller (1976, p. 124) described *Oxalis alpina* as having "the most extensive natural distribution of any species in section *Ionoxalis*" and he viewed the northwestern population system (treated here as *O. metcalfei*) as having attained its present distribution by northward migration from ancestral populations in southern Mexico. He more recently has noted (Weller et al. 2007, p. 974) that "Cytogeographic studies, which have shown that the haploid chromosome number varies from 7 to 42, suggest that *O. alpina* is not monophyletic (Weller and Denton, 1976). In contrast, populations in the Sky Island region of Arizona, New Mexico, and Sonora are likely to be monophyletic based on similar morphology, uniform tetraploidy (Weller and Denton, 1976), and production of viable hybrid seed (Weller, 1978)." Regarding the recent statement, evidence does not appear in any of Weller's publications to support his observation that *O. alpina* is non-monophyletic, unless it is simply the occurrence of polyploidy, nor have his studies provided any morphological comparison between typical *O. alpina* in south-central Mexico and the northern "*O. metcalfei*" variants. Nor is the observation of "uniform tetraploidy" true, since both tetraploids and hexaploids of *O. metcalfei* occur in the Mogollon Range of southeastern New Mexico (Catron and Grant cos.), part of the "Sky Island" region. Hexaploids in *O. metcalfei* apparently occupy the far-eastern portion of the range, compared to the more widely distributed tetraploids, and their morphological identity with the tetraploids suggests that they arose from the latter.

Tristyly appears to be primitive in *Oxalis*, based on the predominance of that condition in diploid endemic species of southern Mexico and the occurrence of distyly mostly in species with broader

distributions and higher ploidy levels (Weller & Denton 1976). Populations of *Oxalis metcalfei* in Arizona, New Mexico, and Chihuahua are tristylous, distantly separated from the closest tristylous populations of any species in Mexico (see Weller & Denton 1976, Fig. 1). Based on success of inter-population crossing, Weller (1978) hypothesized that distylous populations of *O. metcalfei* are derived from tristylous ones in the same region. The distylous populations apparently are restricted to Arizona (Weller 1979; Weller et al. 2007), in the region where only tetraploidy has been reported.

Oxalis alpina (Rose) Rose ex R. Knuth, Notizbl. Bot. Gart. Berlin-Dahlem 7: 315. 1919. *Ionoxalis alpina* Rose, Contr. U.S. Natl. Herb. 10: 110. 1906. **TYPE:** Mexico. Edo. Mexico. Sierra de las Cruces, fir woods, 10,000 ft, 13 Aug 1896, *C.G. Pringle 6439* (holotype: US-digital image!; isotypes: GH!, MO!, NY-digital image!, US-digital image!).

4. *Oxalis latifolia* Kunth in Humboldt, Bonpland & Kunth, Nov. Gen. Sp. 5[quo.]: 237, plate 467. 1821 [1822]. *Acetosella violacea* subsp. *latifolia* (Kunth) Kuntze, Rev. Gen. Pl. 1: 90. 1891. *Ionoxalis latifolia* (Kunth) Rose, Contr. U.S. Natl. Herb. 10: 113. 1906. **TYPE:** Mexico: crecit prope Campeche, no date, *Humboldt and Bonpland s.n.* (holotype: P fiche!; possible isotype: B-Willdenow 8975 fiche!). The leaves of the B-Willdenow specimen are folded but appear to be different in shape from the holotype.

Oxalis divergens var. *amplifolia* Trel. in A. Gray, Synopt. Fl. N. Amer. 1(1): 368. 1897. *Oxalis amplifolia* (Trel.) R. Knuth, Notizbl. Bot. Gart. Berlin-Dahlem 7: 314. 1919 (non [Trel.] Tidestrom 1923). *Ionoxalis amplifolia* (Trel.) Rose, Contr. U.S. Natl. Herb. 10: 110. 1906. **LECTOTYPE** (Denton 1973, p. 532): USA. Arizona. [Pima Co.]: Santa Rita Mts., 1828 m, 9 Jul 1881, *C.G. Pringle 300* (GH!). In the 1897 description of var. *amplifolia*, Trelease regarded it as "n. comb." and cited as a synonym "*O. latifolia*, Trelease, [Mem. Boston Soc. Nat. Hist. 4: 91. 1888], t. 11, f. 12, not HBK.," but in the 1888 publication he had identified the taxon as "10. *O. latifolia*, HBK., Nov. Gen., v. 237, Pl. 467, VAR." If he intended to describe a new variety in 1888, it was an illegitimate attempt since he did not provide an epithet. Thus, the name in Gray's treatment is regarded as a new variety, not a comb. nov. or a nom. nov., and the name "*O.*

latifolia Trelease" has no standing. Denton's lectotypification remains valid, but for *O. divergens* var. *amplifolia*.

Plants perennial, acaulescent, glabrous, from a single bulb, bulb scales (5-)7-9(-11)-nerved, inner thickened and white with hyaline margins. **Leaves** all basal; leaflets 3, obtriangular to obovate, (15-)25-40 mm, lobed 1/5-1/2 length, lobes apically rounded, green on both surfaces, oxalate deposits absent; petioles (6-)10-25 cm. **Flowers** (3-)6-10(-12) in umbelliform cymes, tristylous, rarely homostylous; scapes (7-)10-20(-30) cm; pedicels (5-)10-20(-35) mm; sepal apices with a pair of short to elongate, non-confluent, orange tubercles; petals 9-12 mm, purple to lavender or pink. **Capsules** cylindric, 4-6 mm, glabrous. $2n = 14, 28, 42$ (all counts from Mexico, fide Weller & Denton 1976).

Flowering Jun-Sep(-Oct). Rocky slopes, ledges and crevices, ridge tops, canyons, sandy washes, floodplains, mesquite-baccharis, mesquite-acacia, hackberry-willow, oak-juniper-pinyon, oak-maple, pine-oak woodlands; (1100-)1300-2200(-2800) m. Native to the southwestern USA — Arizona (Cochise, Navajo, Pima, and Santa Cruz cos.), New Mexico (Colfax, Otero, San Miguel, and Taos cos.), and Texas (Brewster, Culberson, and Jeff Davis cos.), Mexico (Chihuahua, Coahuila, Durango, Nuevo León, San Luis Potosí, Sonora, Tamaulipas, Zacatecas, and southward to Chiapas), and Central America; reported to be naturalized in California and on other continents, but identities of these plants all need to be verified.

Collections of *Oxalis latifolia* Kunth (as identified here) from northern Mexico, southwestern Texas, eastern New Mexico, and southern Arizona were identified by Denton (1973) as *O. alpina*, *O. drummondii*, and "*O. aff. drummondii*." *Oxalis drummondii* as mapped by Ornduff and Denton (1998, Fig. 2B) almost certainly is *O. latifolia*. *Oxalis latifolia* sensu stricto occurs widely in Mexico north to all states bordering the USA. Populations in northern Mexico and the USA tend to have more rounded leaflets and apparently do not produce bulblets — they perhaps ultimately may be better identified by a different name, but they are neither *O. alpina* (with bulblet production) nor *O. drummondii* (with 3-nerved bulb scales and different leaf morphology). Denton (1973, p. 572) observed that *O. latifolia* "is probably composed

of a number of races and perhaps includes a number of introgressants with other species.”

Lourteig (2000) recognized four subspecies of *Oxalis latifolia* — her concept of subsp. *latifolia* restricted it to South America and the West Indies (even though the type was collected in Mexico); subsp. *schraderiana* (Kunth) Lourteig is entirely South American; subsp. *vespertilionis* (Zucc.) Lourteig occurs in montane Mexico south to Guatemala; subsp. *galeottii* (Turcz.) Lourteig is the expression that she recognized as occurring into the USA. In contrast, most others, including Denton (1973), have treated *O. galeottii* Turcz. as a distinct species of central and southern Mexico, broadly sympatric with *O. latifolia*.

5. *Oxalis drummondii* A. Gray [nom. nov.], Smithsonian Contr.

Knowl. 5(6): 25. 1853. *Oxalis vespertilionis* Torrey & A. Gray, Fl. N. Amer. 1: 679. 1840 (non Zucc. 1834). **TYPE:** USA. Texas. No other locality data, *T. Drummond III*. 8 (holotype: NY, NY-digital image!). *Oxalis latifolia* subsp. *vespertilionis* (Zucc.) Lourteig (Bradea 7: 591. 2000), a South American taxon, is heterotypic with *O. drummondii*.

Plants perennial, acaulescent, arising from a scaly bulb, glabrous; bulb scales 3-nerved, margins villous-ciliate on distal 1/3–1/2. **Leaves** all basal; leaflets 3, obtriangular to obcordate, (6–)14–34 mm, lobed 1/4–4/5 length, lobes apically convex to nearly truncate, green on both surfaces, sometimes adaxially with red splotches in an irregular medial band, oxalate deposits absent, petioles 5–16 cm. **Flowers** 3–10 in umbelliform cymes, distylous or rarely homostylous; scapes (7–)11–23 cm; sepal apices with a pair (or 3–6) of orange, thickened, apically confluent tubercles; petals (8–)15–23 mm, pink to violet or purple-violet. **Capsules** cylindric, 4–12 mm, pubescent. $2n = 14$.

Flowering Mar–Nov; sandy-gravelly soil, limestone soil, disturbed areas, prairies, limestone hills, open woodlands, chaparral; 20–300 m. Native to Texas and Mexico (Chihuahua, Coahuila, Durango, Nuevo León, Sonora, Tamaulipas).

Oxalis drummondii is recognized by the production of a single bulb with 3-nerved scales, obtriangular leaflets, large flowers, and thick

tubercles at the sepal tips. Attributions of this species to Arizona and southern New Mexico apparently are based on identifications by Denton (1973) of plants from those states as *O. drummondii* and "aff. *O. drummondii*." These collections are identified here mostly as *O. latifolia*. Denton (1973) cited, but did not map, a historical collection (NY) from Oklahoma as *O. drummondii*, significantly disjunct northward from its main range. Recent accounts of the flora of the state have not included the species.

Oxalis madrensis Rose (= *O. leonis* R. Knuth), listed by Denton (1973) as a synonym of *O. drummondii*, is instead a distinctive species (bulblets numerous, bulb scales 5–9-nerved, flowers large, blue, 8–12 per scape), apparently restricted to high elevation habitats in northeastern Mexico and probably closely related to *O. alpina* (Nesom in prep).

6. *Oxalis violacea* L., Sp. Pl. 1: 434. 1753. *Acetosella violacea* (L.) Kuntze, Revis. Gen. Pl. 1: 90. 1891. *Ionoxalis violacea* (Linnaeus) Small, Fl. S.E. U.S. 665, 1332. 1903. **LECTOTYPE (Reveal in Jarvis 2007, p. 717). *Kalm s.n.*, Herb. Linn. No. 600.12 (LINN). The protologue noted "Habitat in Virginia, Canada."**

Plants perennial, acaulescent, arising from a single bulb, rarely producing slender, scale-leaved rhizomes with a bulblet at the tip of each, glabrous, rarely without leaves; bulb scales 3-nerved, margins villous-ciliate on distal 1/3–1/2. **Leaves** all basal; leaflets 3, rounded-obcordate to obreniform, (5–)8–15(–20) mm, lobed 1/4–1/3 length, lobes apically convex, bright green above, often with a purplish, lateral band, slightly paler green to purple beneath, oxalate deposits along the margins only at the base of the notch, petioles (4–)7–13(–24) cm. **Flowers** (1–)2–8(–19) in umbelliform cymes, distylous; scapes (6–)9–23(–31) cm; sepal apices with a pair of narrow, orange, apically confluent tubercles; petals 10–18 mm, rose-purple or lavender to pink or white. **Capsules** ovoid, 4–5 mm. $2n = 28$.

Flowering Apr–May(–Jul) (with leaves) and Aug–Oct (usually without leaves, following rains). Sandy soil, gravelly soils, prairies, limestone glades, hills of granite, limestone, and rocky-clay, rock outcrops, bluffs, bottomland, oak-pine, oak-hickory, live oak, juniper woodland, cutover pine, roadsides, disturbed sites, abandoned fields;

50–400(–1000) m. Native to the eastern USA (Alabama, Arkansas, Connecticut, Delaware, District of Columbia, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Massachusetts, Maryland, Michigan, Minnesota, Missouri, Mississippi, Nebraska, New Jersey, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Virginia, Vermont, West Virginia, and Wisconsin) and Mexico (Coahuila).

Oxalis violacea is restricted in its native range to the eastern USA (barely into Mexico, see below), reaching westward as far as the line of states from North Dakota to Texas. Plants identified by Denton (1973) as *O. violacea* and “aff. *O. violacea*” from Arizona and New Mexico are identified here as *O. metcalfei* and *O. latifolia*. It is possible that her identifications were influenced by an emphasis on the oxalate deposits in the leaflet notches, which occur in *O. violacea* and in *O. metcalfei*, although there is a distinct difference in the morphology and placement of the deposits. Similarly, reports of naturally occurring *O. violacea* in Colorado are based on misidentifications (see county citations from Colorado, above; CU Museum 2009; Emshwiller et al. in press). In noting its occurrence in Wyoming (Dorn 2001, p. 259) observed that it has been “collected only once, in 1881 or 1882” in Yellowstone National Park — if correctly identified, this record surely was from a planting. Denton (1973, p. 606) cited the collection: “Wyoming: Park Co: [not mapped, probably introduced] Yellowstone Nat. Park, fl. 1881-1882, *Forwood US-317388* (US).”

Young (1958, p. 63) noted that “There is no evidence that [*Oxalis violacea*] has ever occurred in Britain as a wild plant, and it should be removed from the British list. Chevalier (1940, p. 682) was likewise of the opinion that French records for it were erroneous.” Liogier (1988) reported that *Oxalis violacea* is “cultivated and escaped in Puerto Rico” — collections have not been seen in the present study to confirm or dispute that.

Denton (1973) did not report *Oxalis violacea* in Mexico, but two collections unequivocally identified as that species have been made from northern Coahuila along the Rio Grande, immediately across the river from eastern Brewster County, Texas. These two sites are only

slightly southwest from an apparently disjunct locality at the southwestern extremity of the USA range of *O. violacea*. **Texas.** Val Verde Co.: ca. 10 mi W of Comstock on U.S. Highway 90, floor of Seminole Canyon, ca. 0.5 mi above its confluence with Presa Canyon, Seminole Canyon State Historical park, 16 Oct 1988, *Labus 379* (TEX). **Mexico. Coahuila.** In hills just across the river from mouth of Maravillas Creek, Black Gap Wildlife Management Area (Brewster Co.), 29° 33' 29-34"N, 102° 45-46"W, steep limestone slopes of Rio Grande canyon and tributaries, 500-950 m, *Dasyllirion*, *Agave*, *Acacia*, *Larrea*, 6 Apr 1973, *Johnston et al. 10589½N* (TEX); one of the deepest parts of Boquillas Canyon, below (downstream from) Cave of the Blessed Virgin, 29° 13'N, 102° 54' 30"W, very steep limestone slopes, 770 m, *Dasyllirion*, *Agave*, *Karwinskia*, *Hechtia*, 19 Oct 1973, *Johnston et al. 12359* (TEX).

7. *Oxalis debilis* Kunth in A. Humboldt et al., Nov. Gen. Sp. 5(qto.): 236. 1821. *Acetosella debilis* (Kunth) Kuntze, Rev. Gen. Pl. 1: 92. 1891. **TYPE:** Venezuela. Inter La Venta Grande et urbem Caracas, alt. 550 hex, Jan 1800, *Humboldt & Bonpland [681]* (holotype: P fiche!).

Oxalis martiana Zucc., Denkschr. Königl. Akad. Wiss. München 9: 144. 1825. *Ionoxalis martiana* (Zucc.) Small, Fl. S.E. U.S. 665. 1903. **TYPE:** Brazil. Rio de Janeiro, prope Sebastianopolis, *Martius s.n.* (holotype: M). Fide Denton (1973) and Lourteig (2000).

Oxalis corymbosa DC., Prodr. 1: 696. 1824. *Oxalis debilis* var. *corymbosa* (DC.) Lourteig, Ann. Missouri Bot. Gard. 67: 840. 1980 [1981]. *Oxalis debilis* subsp. *corymbosa* (DC.) O. Bolòs & Vigo, Fl. Països Catalans 2: 286. 1990. **LECTOTYPE** (Lourteig 1981): Insula Borbona etc. (G-DC fiche!). The protologue noted "in ins. Borboniae et Mauritiï" — Bourbon Island, now called Réunion, is a volcanic island east of Madagascar and southwest of Mauritius. Marais (1987) noted that *O. debilis* occurs on three of the Mascarene Islands (La Réunion, Maurice, Rodrigues) and is an "Espèce Sud-américaine, anciennement introduite et naturalisée (un échantillon de Commerson du Gol à La Réunion, de 1771)."

Plants perennial, acaulescent, moderately villous to glabrate, arising from a dense cluster of sessile bulblets; bulb scales 3-nerved. **Leaves** all basal; leaflets 3, rounded-obcordate, 17-40(-50) mm, lobed

1/6–1/5 length, lobes apically convex, adaxially hirsute, green to yellowish-green on both surfaces, oxalate deposits usually tiny, often dark, distributed at least around margins of distal 1/3 and often evenly over whole surface, petioles 10–25 cm. **Flowers** (3–)8–14(–28) in irregular cymes, mostly homostylous in North America or infrequently tristylous; scapes 15–28 cm; sepal apices with a pair of orange tubercles; petals 10–16(–20) mm, violet to lavender or rose-purple. **Capsules** not observed, apparently sterile in North America. $2n = 14$ and 28, 35 rarely, and dysploids reported (see Luo et al. 2006 for a summary; no counts known from North America).

Flowering Dec–May, rarely again in the summer. Fencerows, yards, flower beds, roadsides, disturbed areas, hammock margins, sandy live oak woods, mesic woods, creek and river terraces; 5–100 m. Native to South America. Naturalized in California and Washington and in the southeastern USA (Alabama, Florida, Georgia, Mississippi, Louisiana, South Carolina, and Texas); naturalized also in Mexico, Bahamas, West Indies, Central America, Europe, southeastern Asia, Australia, and various Pacific Islands.

The range *Oxalis debilis* in the USA is extended here to include **California**: Marin County: Bolinas, weed in Dennis Breedlove's garden, 3 May 1993, *Best 1459* (CAS). In August 2008, I observed *Oxalis debilis* growing in a garden, apparently without cultivation, at the University of Washington Botanical Gardens in Seattle, Washington. As I was looking closely at the plants, a Seattle resident told me that this species was an abundant weed in and around his home there. The occurrence of the species in Washington, however, apparently has not been documented by a voucher.

Oxalis debilis is known as a naturalized element of the USA flora primarily in coastal states of the Southeast, from South Carolina to Georgia and Florida and westward to Texas. It usually can be unequivocally identified by its acaulescent habit, the plants arising from a cluster of small, sessile bulblets, its large, rounded leaflets with tiny, dark, oxalate deposits scattered evenly over the surface and/or crowded near the margins, and its purplish to violet flowers in an irregularly cymose inflorescence. In addition to those in the basal cluster, bulblets apparently also can be formed at the tips of filiform roots or rhizomes.

Plants can form large, dense colonies and the species appears to be aggressively spreading in the USA. Lourteig (1981, p. 841) noted that "This is a South American species widespread in the whole world, occasionally fruiting but reproducing through abundant bulbils developing simultaneously."

Oxalis debilis most commonly has been identified as *O. corymbosa* or *O. debilis* subsp. *corymbosa*. In expanding *O. debilis* to include *O. corymbosa* at varietal rank, A. Lourteig (1981) provided no comment in explanation, but as later described by her (2000), the two taxa are differentiated primarily by the distribution of oxalate deposits in the leaf lamina. In *O. debilis*, the dot-like deposits are crowded along the margins and absent to distinctly less abundant elsewhere. In *O. corymbosa*, the deposits are evenly distributed over the whole lamina. In their native range in South America, the two expressions are broadly sympatric and intermediates are common, as they are in the USA. *Oxalis corymbosa* sensu stricto appears to be the more commonly naturalized form, but the *O. debilis* expression occurs at least in North America, Asia, Africa, and Central America (collections at MO). Intermediates have the oxalate "dots" along the margins as well as over the whole surface or sometimes mostly on the outer third of the blades, near the margins. Annotations by Lourteig tend to identify both expressions as "*O. debilis* var. *corymbosa*." Without more convincing evidence that the variation is not populational in nature, all plants are identified here simply as *O. debilis*. An analogous pattern of variability in distribution of foliar oxalate 'dots' occurs at least in *O. alpina* (Rose) Rose ex R. Knuth of central Mexico and in the more widely distributed *O. tetraphylla* Cav.

- 8. *Oxalis intermedia*** A. Rich., Hist. Phys. Cuba, Pl. Vasc. 315. 1841.
Ionoxalis intermedia (A. Rich.) Small, N. Amer. Fl. 25: 43. 1907.
TYPE: Cuba, no date, *de la Sagra s.n.* (holotype: P; isotype: P).

Plants perennial, acaulescent, rarely without leaves, glabrous or sparsely pubescent, arising from a cluster of brownish sessile-appearing bulblets or a bulb producing numerous slender stolons with bulblets at the apices; bulb scales (3-)5-7-nerved. **Leaves** all basal; leaflets 3, obtriangular to broadly obtriangular, 20-50 mm, lobed 1/5-1/3 length, lobes apically truncate, bright green above, paler beneath,

oxalate deposits absent; petioles 10–22 cm. **Flowers** 3–12(–18) in umbelliform cymes, semi-homostylous; scapes 7–30 cm; sepal apices with a pair of orange tubercles; petals 8–12 mm, usually lavender to purple, less commonly pink or white. **Capsules** ellipsoid, 3–8 mm, glabrous, usually seed-sterile and without fruit. $2n$ = unknown.

Flowering Apr–Sep. Gardens, lawns, fields, orchards, roadsides, fencerows, moist waste areas; 5–100 m. Native to the West Indies. Naturalized in California, Florida, Louisiana, and Texas; naturalized also in Mexico (Chiapas, San Luis Potosí, and Veracruz). Adams (1988) described the Caribbean range as “Bahamas, Cuba, Puerto Rico, Virgin Is. and southwest to Martinique, also in Trinidad.”

The type collection of *Oxalis intermedia* was made in Cuba and the native range of the species is in the West Indies. It previously has been known as a naturalized member of the USA flora from Florida (Small 1933; Wunderlin & Hansen 2009; USDA, NRCS 2008). The range of the species in the USA is extended here by reports of collections made from California, Louisiana, and Texas. It also has been collected from Massachusetts, but it has not been confirmed as naturalized since the original collection. The species (as *O. latifolia* Kunth) is reported by Wunderlin and Hansen (2009) to occur in 14 additional counties of Florida; a representative collection is cited below for the state. In addition to its naturalization along the Gulf Coast of the USA, *O. intermedia* also grows outside of cultivation in Veracruz (Denton 1973) and San Luis Potosí (SMU!), Mexico.

California. Marin Co.: garden at Ross Station, 3 Jun 1934, *Eastwood s.n.* (GH); weed in garden at [Ross] Station, 5 Aug 1934, *Rose 34459* (GH). **Florida.** Alachua Co.: locally common in shaded, rich loamy soil of hammock just NE of state park office bldg., Alachua Sink—Paynes Prairie State Preserve, on SSE side of Gainesville, 27 Jun 2000, *Anderson 19359* (MO). **Louisiana.** East Baton Rouge Par.: [city of Baton Rouge]: infrequent in oak woods 1 mi S of Louisiana State University on Nicholson Drive, plants never observed flowering, 22 Feb 1975, *McReynolds s.n.* (MO); in a ditch at the intersection of Acadian Thruway and I-12, 24 Sep 1974 [sterile], *McReynolds s.n.* (MO); Concordia Par.: Haphazard Plantation, off La. 566, 11 Aug 1971, *Thomas et al. 24560* (NLU). **Massachusetts.** Essex Co.:

Newburyport, around greenhouses, subhardy, Oct 1940, *McGregor s.n.* (GH). **Texas.** Webb County: Laredo, sandy soil, 23 Feb 1964, *Arizmendi 33* (LL); Laredo, sandy loam, 24 Nov 1962, *Solis 102* (TEX); Laredo, Sanders Street, hard-packed loam, 27 Nov 1961, *Vega and Hilario s.n.* (TEX).

Oxalis intermedia is recognized by its large, green, obtriangular leaves (usually with acute angles), numerous, small, purplish flowers, and clusters of bulblets. It “reproduces chiefly by bulblets as all of the collections are seed sterile except for two specimens from Veracruz” (Denton 1973, p. 556). *Oxalis intermedia* has been treated as a synonym of *O. latifolia* by Lourteig (1980), Howard (1988), Liogier (1988), and Wunderlin and Hansen (2008), but in the assessment here, and following Adams (1972), Denton (1973), Correll & Correll (1982), and Ward (2004), they are different species. The native range of *O. latifolia* is Central America and Mexico, reaching into Arizona, New Mexico, and Texas of the southwestern USA (see discussion above); compared to *O. intermedia*, it generally has smaller, differently shaped leaves and differs in its reproductive biology and ecology.

1. Leaflets obtriangular to broadly obtriangular, (20–)30–50 mm long, 1.5–2.5(–3) times wider than long; stems and leaves arising from a cluster of small sessile bulblets; capsules and seeds rarely formed; flowers semi-homostylous; West Indies, and Veracruz, Mexico, introduced in southeastern USA.....***Oxalis intermedia***
1. Leaflets obcordate to obtriangular, 15–40 mm long, 1.1–2(–3) times wider than long; stems and leaves usually arising from a single bulb, rarely producing additional sessile bulblets; capsules and seeds often formed; flowers tristylous, rarely homostylous; southwestern USA, Mexico, Central America south to Panama.....***Oxalis latifolia***
9. ***Oxalis triangularis*** A. St.-Hil., Fl. Bras. Merid. (qto. ed.) 1: 102. 1825. **TYPE:** Brasil. Rio de Janeiro, inter saxa ad ripas fluvii uba, alt. circiter 600 p., Voyage 1816-21, *St. Hilaire A1 585 X* (holotype: P; isotype: P). Fide Lourteig (2000).
Oxalis triangularis A. St.-Hil. subsp. *papilionacea* (Hoffmannsegg ex Zucc.) Lourteig, in L.B. Smith, Fl. Ill. Catarin., Oxalidaceae 101. 1983. *Oxalis papilionacea* Hoffmannsegg ex Zucc., Akad. Wiss.

- Wien, Math.-Naturwiss. Kl., Denkschr. 9: 148. 1825. **TYPE:** Brasil. Pará, im unbrosis, *Hoffmannsegg ex herb. Martii 18* (holotype: M). Fide Lourteig (2000).
- Oxalis palustris* A. St.-Hil., Fl. Bras. Merid. (qto. ed.) 1: 127. 1825. **TYPE:** Brasil. Minas Gerais, Desert du Río S. Francisco, contendas, marais après Olho d'Água, in paludosis, Voyage 1816-21, *St. Hilaire* (holotype: P; isotype: P). Fide Lourteig (2000).
- O. regnellii* Miq., Linnaea 22: 545. 1849. **TYPE:** Brasil. Caldas, *Regnell 1143* (holotype: S; isotype: P). Fide Lourteig (2000).
- O. catharinensis* N.E. Br., Gard. Chron. ser. 3, 1: 140. 1887. *Oxalis regnellii* var. *catharinensis* (N.E. Br.) Norlind, Ark. Bot. 14: 10. 1915. **TYPE:** Brasil. Santa Catarina, cult. in Kew Gard., 1887, *N.E. Brown* (holotype: K). Fide Lourteig (2000).

Plants perennial, acaulescent, arising from short, branching rhizomes ca. 1 cm in diam. and covered with thickened, overlapping scales, sometimes with a cluster of bulblets at the rhizome base, rarely without leaves; rhizome and bulb scales (1–)3-nerved, glandular along the margins. **Leaves** all basal; leaflets 3, obtriangular to obovate-triangular, (20–)30–50(–60) mm, lobed ca 1/10 length or apex merely notched, lobes apically truncate to slightly convex, dark purple on both surfaces, commonly with lighter violet splotches adaxially, radiating from the midvein, oxalate deposits absent or as short, filiform, marginal lines on both sides of the notch, petioles 12–20 cm. **Flowers** (1–)2–5(–9) in umbelliform cymes, heterostylous; scapes 15–35 cm; sepal apices with a pair of orange tubercles; petals 15–22 mm, white to pinkish or pale purple. **Capsules** ovoid-ellipsoid, 12–18 mm. $2n$ = unknown.

Flowering Apr–May. Disturbed sites, near gardens; 5–100 m. Native to South America (Argentina, Bolivia, Brazil, Paraguay, Peru?). Introduced in Florida and Louisiana.

In East Feliciana Parish, Louisiana, north of Baton Rouge, *Oxalis triangularis* has spread from a planter pot into adjacent woods (Gerald Guala, pers. comm.). In Leon County, Florida, a population is growing and slowly spreading at the edge of a woodland remnant within the city of Tallahassee (Loran Anderson, pers. comm.).

Lourteig (2000) recognized two subspecies closely sympatric over much of their native ranges (as cited, subsp. *triangularis* in Argentina, Bolivia, Brasil, and Paraguay, subsp. *papilionacea* in Bolivia, Brasil, Paraguay, and Peru) and differing by the following contrasts.

- a. Sepals acute, oxalate tubercles small or absent; petals white to purplish, 3–4 times longer than the sepals...
.....***Oxalis triangularis* subsp. *triangularis***
- a. Sepals obtuse to subacute, oxalate tubercles thickened; petals pink to purplish, rarely white, about 2–2.5 times longer than the sepals...
.....***Oxalis triangularis* subsp. *papilionacea***

I have seen relatively few collections of *O. triangularis* in this study, but with these subtle differences and broad sympatry, it seems probable that only a single evolutionary entity exists. In any case, the few North American cultivated collections studied here would be *O. triangularis* sensu stricto. Forms of *O. triangularis* are sometimes recognized as “*atropurpurea*” but this apparently is a horticultural name.

- 10. *Oxalis articulata*** Savigny in Lam., Encycl. 4: 686. 1797 [1798]. Uruguay. Montevideo, in pascuis, May 1767, *Commerson s.n.* (holotype: P-Juss.; isotype: P). Fide Lourteig (1982, 2000).
Oxalis rubra A. St.-Hil., Fl. Bras. Merid. (quarto ed.) 1: 124. 1825.
Oxalis articulata subsp. *rubra* (A. St.-Hil.) Lourteig, Phytologia 50: 137. 1982. **TYPE:** Brazil. “Inveni ad ripas rivulorum prope pagulum Freguesia Nova, in parte australi provinciae S. Pauli quam dicunt Campos Gerães. Floret Martio, Voyage 1816-21, *St. Hilaire C*² 1587 (holotype: P; isotype: P). Fide Lourteig (1982, 2000).

Plants perennial, acaulescent, sparsely strigose, arising from a thick, woody, irregularly nodulate-segmented rhizome often with persistent, thickened, and lignescent petiole bases. **Leaves** all basal; leaflets 3, rounded-obcordate, 18–20 mm, lobed 1/5–1/3 length, lobes apically convex, bright green above, slightly paler green to purplish beneath, evenly strigose-villous to strigose-hirsute on both surfaces, oxalate deposits concentrated mostly toward the margins or over the whole surface, margins densely loosely ciliate, petioles 11–30 cm.

Flowers 3–12 in umbelliform cymes (often up to 100 inflorescences per plant), less commonly in irregular cymes, heterostylous; scapes 12–28 cm; sepal apices with a pair of orange tubercles; petals 10–14 mm, purplish rose to red, sporadically white. **Capsules** ovoid, 4–8 mm. $2n = 42$.

Flowering Mar–Jul. Disturbed places, especially near gardens, lawns, fields, roadsides; 5–250 m. Native to South America (Argentina, Brazil, Uruguay). Naturalized in Alabama, Arkansas, California, Florida, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, Oregon, South Carolina, Texas, and Virginia; naturalized also in Europe, Australia, Pacific Islands (New Zealand). Lourteig (1982) also cited collections from Arizona, Maryland, Pennsylvania, and Washington; among these, the collection from Washington perhaps was from a naturalized population, the others surely cultivated.

This species in the USA commonly has been identified as *Oxalis rubra*. *Oxalis rubra* was treated as a subspecies of *O. articulata* by A. Lourteig (1982, 2000), but in her specimen citations and range descriptions, subsp. *articulata* and subsp. *rubra* have essentially the same native range and occur in similar habitats. Lourteig identified both subspecies in the USA, noting in her key that vestiture is reduced and the sepals are broader in subsp. *rubra*, but I am unable to distinguish two entities in the USA and evidence appears weak for recognizing more than a single entity. She recognized only *O. articulata*, without infraspecific taxa, in the Flora of Panama (Lourteig 1981).

The inclusion of Oregon in the naturalized range of *Oxalis articulata* is based on the following collection: Coos Co.: E end of Brandon, 3rd St. SE near Michigan Ave. SE, lawn weed, 25 m elev., 17 May 2004, Zika 19622 (MO).

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**NOTES ON *OXALIS* SECT. *CORNICULATAE* (OXALIDACEAE)
IN THE SOUTHWESTERN UNITED STATES**

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ABSTRACT

Oxalis californica, *O. pilosa*, and *O. albicans* are distinct species of the southwestern USA and Mexico. Geographic summaries are provided and a species key includes these as well as *O. corniculata*, *O. dillenii*, and *O. stricta*, which also occur in the area. *Oxalis californica* is documented from south-central Arizona by collections from closely adjacent sites in Pinal and Maricopa counties in the Superstition Wilderness Area. Outside of its native range in California, and Arizona, and southwestern New Mexico, *O. pilosa* is reported from probable adventive occurrences in Nevada, Utah, and Oregon. *Oxalis albicans* is documented as an adventive in southern California. *Phytologia* 91(3): 527-533 (December, 2009).

KEY WORDS: *Oxalis albicans*, *Oxalis californica*, sect. *Corniculatae*, southwestern USA

Eiten (1963) treated *Oxalis albicans* Kunth, *O. pilosa* Nutt. ex Torr. & A. Gray, and *O. californica* (Abrams) R. Knuth as subspecies within a single species (*O. albicans*), emphasizing their similarities and putatively close evolutionary relationship. Lourteig (1979) subsumed both *O. albicans* and *O. pilosa* within the nearly cosmopolitan *O. corniculata* L., maintaining *O. californica* as a separate species. As at least implicitly recognized by both Eiten and Lourteig, and as emphasized here, *O. albicans* and *O. pilosa* are sympatric in Arizona and northeastern Mexico and *O. pilosa* and *O. californica* are sympatric in southern California. Considerable variability exists in *O. albicans* and *O. pilosa*, but the variation does not appear to be chaotic and where they are sympatric, intermediates between *O. albicans* and *O. pilosa* and between *O. pilosa* and *O. californica* appear to be relatively

uncommon. All (apparently) who have studied *Oxalis* in Arizona, where both the “albicans” and “pilosa” expressions occur widely and are represented by many collections, have agreed that two taxa are present. Evidence thus suggests that these taxa are reproductively isolated and that each of the three is appropriately treated at specific rank. The aim of the present report is primarily to document the major outlines of the geographic distribution of these species and to provide a guide toward their identification.

Oxalis dillenii Jacq. and *O. stricta* L., species native to the eastern USA, occur sporadically in western localities (Nesom 2009), presumably as adventives. In the southwestern USA, where plants of the *O. albicans* group occur, the PLANTS Database (USDA-NRCS 2009) records *O. stricta* from Arizona and New Mexico but I have not seen vouchers from those states; Ornduff and Denton (1998) cited Coconino Co. and Maricopa Co. for *O. stricta*.

Oxalis corniculata in the USA is recognized by its sparsely hairy stems creeping and rooting at nodes, all procumbent and radiating from the taproot, and its well-developed stipules with broad, free margins and auricled apices. Peduncles and 1(–3) leaves are produced at the nodes, short erect stems rarely. In the southwestern USA, it is an adventive that occurs sporadically as a lawn weed and in the vicinity of other horticultural endeavors. A form of *O. corniculata* (as collected and identified by George Eiten, numerous specimens at SMU) is common in central Mexico (collections seen from Hidalgo, Jalisco, Edo. Mexico, Michoacan, Morelos, and Queretaro) — these plants produce large, prominent stipules and nearly glabrous stems, but the habit varies from procumbent to ascending and the stems rarely root at the nodes. This expression apparently is a native form and perhaps has not been formally named.

Key to species of *Oxalis* sect. *Corniculatae* in the southwestern USA

1. Flowers usually (3–)5–7(–15) in regular or irregular cymes; stems with septate hairs on stems and petioles, sometimes few and concentrated at nodes, sometimes only on petioles....***Oxalis stricta***
1. Flowers 1 or 2–3 in umbelliform cymes; stems with only non-septate hairs.

2. Stems (at least on the proximal half) usually densely strigose with stiff, antrorsely closely appressed hairs.....**Oxalis dillenii**
2. Stems glabrous to glabrate, puberulent to hirsutulous-puberulent, or pilose.
3. Stems mostly prostrate, often rooting at the nodes, mostly radiating from a central point, taproot rarely becoming thick-woody; stipules with wide, free margins and apices.....**Oxalis corniculata**
3. Stems erect or erect and decumbent to prostrate, sporadically rooting at the nodes or not; stipules obsolescent or with very narrow, free margins, apices completely truncate, obsolescent.
4. Stems glabrous to very sparsely puberulent; peduncles 2–9 cm; sepals glabrous; stipules at midstem with narrow, free margins; flowers 1(–3).....**Oxalis californica**
4. Stems puberulent or pilose; peduncles 1.5–5 cm; sepals strigose to hirsute-strigose; stipules at midstem obsolescent or with narrow, free margins; flowers 1–2(–3).
5. Stems puberulent to hirsutulous-puberulent, hairs usually upcurved or crisped, sometimes straighter, longer hairs 0.2–0.3(–0.8) mm; stipules at midstem obsolescent or with very narrow, free margins**Oxalis albicans**
5. Stems sparsely to densely pilose, hairs spreading, irregularly oriented to somewhat regularly deflexed, longer hairs mostly 0.6–1.2 mm; stipules at midstem consistently with very narrow, free margins**Oxalis pilosa**

OXALIS CALIFORNICA (Abrams) R. Knuth, Notizbl. Bot. Gart. Berlin-Dahlem 7: 300. 1919.

Xanthoxalis californica Abrams, Bull. Torrey Bot. Club 34: 264. 1907.

Oxalis albicans subsp. *californica* (Abrams) Eiten, Amer. Midl.

Naturalist 69: 303. 1963.

Oxalis californica var. *subglabra* Wieg., Rhodora 27: 119. 1925.

Flowering (Dec–)Feb–Apr(–Jun). Slopes and flats, brushy ridges, roadside banks, canyon bottoms, rock outcrops, grassland, oak chaparral, coastal sage scrub; (5–)30–800 m; Arizona, California; Mexico (Baja California).

Oxalis californica is recognized by its caulescent stems with reduced vestiture (glabrous to very sparsely short-puberulent), 1(–3) yellow flowers on long peduncles and pedicels, the corollas often drying with a blue or purplish tinge, and relatively wide, glabrous, and usually purplish- or pinkish-tinged sepals.

In California, *Oxalis californica* is known to occur in Los Angeles (including Santa Catalina Is.), Orange, Riverside, San Bernadino, San Diego, Santa Barbara (including Santa Cruz Is.), and Ventura counties. Plants of typical *O. californica* also have been collected in natural habitats at two sites in south-central Arizona, about 450 kilometers east of the closest localities in its previously known range in southern California and northern Baja California.

Maricopa Co.: Tonto National Forest, Superstition Wilderness Area, Fish Creek Canyon, ca. 2 mi from Tortilla Trailhead on Ariz Hwy 88, associated with *Populus fremontii* *Platanus wrightii*, *Cephalanthus occidentalis*, *Morus microphylla*, growing on steep, rocky slope, 2800 ft, 15 Mar 1993, *Rice 1604* (ASU). **Pinal Co.:** Tonto National Forest, Superstition Wilderness Area, Massacre Grounds, Forest Rd 78, ca. 1 mi to turnoff, T1N R9E S5SE, associated with *Ambrosia*, *Dodonea viscosa*, *Encelia farinosa*, *Lycium*, *Quercus turbinella*, 2400 ft, 5 May 1992, *Rice 1209* (ASU). Lourteig (1979) also recorded a collection of *O. californica* from Arizona: **Maricopa Co.**, Mesquite Creek, ca. 1 mi E of Tortilla Flat, ca. 1500 ft, 31 Mar 1963, *Halverson 54* (BM).

Oxalis pilosa Nutt. is similar in habit to *O. californica* and occurs abundantly in the Superstition Wilderness Area in localities close to those of *O. californica*: **Maricopa Co.**— *Rice 1425* (ASU); **Pinal Co.**— *Rice 249, 356, 729, 1695, 1698* (all ASU). It is distinguished from *O. californica* by its pilose stems, shorter peduncles and pedicels, and narrower, strigose, gray-green sepals.

OXALIS PILOSA Nutt. ex Torr. & A. Gray, Fl. N. Amer. 1(2): 212. 1838.

Oxalis albicans subsp. *pilosa* (Nutt. ex Torr. & A. Gray) Eiten, Amer. Midl. Naturalist 69: 303. 1963.

O. corniculata subsp. *pilosa* (Nutt. ex Torr. & A. Gray) Lourteig, Phytologia 42: 134. 1979.

O. corniculata var. *pilosa* (Nutt. ex Torr. & A. Gray) B.L. Turner, Phytologia 77: 4. 1994.

O. wrightii A. Gray var. *pilosa* (Nutt. ex Torr. & A. Gray) Wieg., Rhodora 27: 120. 1925.

Flowering (Feb–)Mar–Jun(–Oct). Juniper-grassland, pinyon-juniper, oak-juniper, oak, oak-pine, rocky and grassy hillsides, riparian woods (sycamore-walnut, cottonwood-willow), canyons, streamsides, washes, gravel bars; (700–)900–1900(–2000) m; Arizona, California, New Mexico, Nevada, Oregon, Utah; Mexico (Baja California, Chihuahua, Coahuila, Durango, Nuevo León, Sonora).

The native distribution *Oxalis pilosa* is primarily in Arizona, southern California, and northwestern Mexico — it occurs as a probable adventive in peripheral localities, documented here.

Nevada. Washoe Co.: Reno, sidewalk weed, 6 Jul 1980, *Tiehm 6142* (MO). **New Mexico.** Hidalgo Co.: Peloncillo Mts., Guadalupe Cyn, 7 Apr 1979, *Spellenberg 5072* (NMC, as reported by Spellenberg et al. 1986). **Oregon.** Benton Co.: Corvallis, weed in garden, 7 Oct 2005, *Halse 6888* (ASU). **Utah.** Washington Co.: St. George, lawn of McQuarrie Memorial Hall, 2800 ft. 9 Sep 1947, *Galway 2215G* (SMU). Turner's view of *O. corniculata* var. *pilosa* as widespread through Mexico (1994) is not corroborated in the present study, which indicates that it primarily occurs in northwestern Mexico, with scattered localities to the east in Nuevo León.

OXALIS ALBICANS Kunth, Nov. Gen. Sp. 5(qto.): 244. 1822

Oxalis corniculata subsp. *albicans* (Kunth) Lourteig, Phytologia 42: 137. 1979.

Oxalis wrightii A. Gray, Smithsonian Contr. Knowl. 3(5): 27. 1852.

Oxalis corniculata var. *wrightii* (A. Gray) B.L. Turner, Phytologia 77: 3. 1994.

Oxalis pilosa var. *wrightii* (A. Gray) Wieg., Rhodora 28: 67. 1926.

Flowering Apr–Aug(–Oct). Desert scrub, grasslands, mesquite-acacia, pinyon-juniper, oak-pine-juniper, oak-buckthorn, riparian woodland (sycamore-hackberry-walnut-ash-willow), creek

sides, meadows, washes, hillsides, ravines, canyons, disturbed sites; (600–)700–1900(–2100) m; Arizona, California, New Mexico, southwestern Texas; widespread in Mexico.

Oxalis albicans is uncommon in California, documented by the following collection: Los Angeles Co., foothills of San Gabriel Mts., West Debris Basin, Brown School for Girls, rocky S slope, 1500 ft, 21 Mar 1968, *Wheeler s.n.* (ASU).

Turner's concept of *Oxalis corniculata* var. *wrightii*, judging from his map (1994, Fig. 1) appears mostly to comprise western populations of *O. dillenii* Jacq., although *O. wrightii* sensu stricto (typified by a collection from Jeff Davis Co. in trans-Pecos Texas) is a synonym of *O. albicans*. The morphological concept here of *O. albicans* is essentially similar to that of Eiten (1963) and of Lourteig (1979, mostly from the geographical range circumscribed by her specimen citations).

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THE GENERIC DISPOSITION OF THE AFRICAN *VERNONIA*
BIAFRAE Oliv. & Hiern
(VERNONIEAE: ASTERACEAE).

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ABSTRACT

Vernonia biafrae of West and Central tropical Africa is transferred to the genus *Distephanus*. *Phytologia* 91(3): 534-536 (December, 2009).

KEY WORDS: Africa, Vernonieae, Asteraceae, *Vernonia biafrae*, *Distephanus*.

Two points are important regarding the Vernonieae of Africa. First, none of the native species that has been called *Vernonia* in Africa truly belong to that genus (Robinson 1999a, b); and second, the alternative taxonomy remains incomplete. For the present, only some of the needed segregates have been properly established or defined (Robinson 1999a, 2007, 2009). One other author, Isawumi (2008), who has direct access to many of the species, has been able to make some further changes. A disposition is provided here for one additional species, *Vernonia biafrae* Oliv. & Hiern.

Vernonia biafrae has been described as shrub or small tree, occurring in West and Central tropical Africa from the areas of Nigeria, Kameroon, Gabon, Equatorial Guinae, Sudan, Ethiopia, Kenya, Uganda, Tanzania, Zambia, and Malawi. In the most general way, its habit resembles plants of the *Vernonia zanzibarensis* Less. relationship, but details, such as the acute-tipped sweeping hairs on the styles and structure of the achene wall, belie any close relation. No attempt was made to place the species by Robinson (1999a) in the first effort to realign the African Vernonieae.

In Jones (1981), *Vernonia biafrae* was placed in *Vernonia* subsection *Pawekianae* S.B. Jones. This subsection was typified by *Vernonia angulifolia* DC.

Jeffrey (1988), in the text of his study, placed *Vernonia biafrae* in his "*Vernonia* group 2 subgroup B, third aggregate" with mostly persistent inner involucre bracts, ca. 5-ribbed achenes, and ovate to cordate leaves. This "aggregate" included subsection *Pawekianae* of S.B. Jones. In a comment under the species, Jeffrey suggested that *V. biafrae* might be conspecific with the South African *V. angulifolia*. In fact, *V. angulifolia*, though superficially very similar, differed by having trinervate or triplinervate leaves, and was already placed in *Distephanus* Cass. by Robinson & Kahn (1986). An examination of *V. biafrae* shows that it has little in common with other species in the "aggregate" in which it was placed by Jeffrey (1988), an aggregate consisting primarily of *V. zanzibarensis* Less. and its close relatives. However, the papery, persistent, blunt involucre bracts with a median dark line, and the multiply pseudodichotomous branching of the inflorescence are almost identical to the condition in *Distephanus angulifolia* (DC.) H. Rob. & Kahn, and some of its close relatives such as *D. anisochaetoides* (Sond.) H. Rob. & Kahn. Thus, Jeffrey's placement of the species in his treatment was incorrect, but his comment under the species seems to have identified the correct relationship.

A problem still remains in the placement of *V. biafrae*. *Distephanus* is mostly defined by its trinervate or triplinervate leaf venation and by its yellow florets. The leaves of *V. biafrae* are strictly pinnately veined, and its florets are reddish to purplish, as in most of the other genera of the Vernonieae. There are exceptions to these characters in some *Distephanus*, especially in those species in continental Africa, species that often lack yellow corollas. Proof will await DNA sequencing, but for the present, it seems that the placement of Jones (1981) and the comment by Jeffrey (1988) have proven essentially correct. The transfer is as follows.

Distephanus biafrae (Oliv. & Hiern) H. Rob., **comb. nov.** Basionym: *Vernonia biafrae* Oliv. & Hiern, in Oliver, Fl. Trop. Afr. 3: 270. 1877.

Vernonia tufnelliae S. Moore, J. Bot. 46: 292. 1908.

- Vernonia leptolepis* O. Hoffm. in Engl., Pflanzenw. Ost. — Afr. C. 405. 1895. As indicated by Jeffrey (1988), neotypification is needed. Such neotypification awaits more appropriate material. I follow Jeffrey (1988) in his doubt about this synonym. The Hoffmann (Engler 1895) description of the involucre bracts, "oblongis obtusis pallidis, nervo obscuriore percursis . . ." certainly applies, but description of the leaves as, "lanceolatis vel ovato-lanceolatis plerumque obtusis . . ." seems wrong unless the word "obtusis" applied to something other than the leaf apex.
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**CHUCOA ILICIFOLIA, A SPINY ONOSERIS (ASTERACEAE,
MUTISIOIDEAE: ONOSERIDEAE)**

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ABSTRACT

Molecular phylogenetic studies of several members of Mutisioideae show that the type species of the genus *Chucoa* of northern Peru is a member of the genus *Onoseris*. The combination *Onoseris ilicifolia* is proposed. The disposition of the second species of *Chucoa* awaits molecular studies. *Phytologia* 91(3): 537-541 (December, 2009).

KEY WORDS: *Chucoa*, *Onoseris*, Onoserideae, Mutisioideae, Andes, Peru.

Mutisioideae, a taxon first circumscribed based on molecular phylogenetic analysis (Panero and Funk 2008), includes approximately 44 genera and 630 species. The subfamily contains three main lineages recognized at the tribal level: Mutisieae, Nassauvieae and Onoserideae. The monophyly of Mutisioideae has not been confirmed, as a few genera that share morphological features found in this taxon have not yet been included in molecular analyses, and hence our understanding of their relationships remains tentative. Among these unsampled taxa is the genus *Chucoa*, a seldom-collected species endemic to the Santiago de Chuco region of La Libertad Department in northern Peru.

Chucoa was described by Cabrera (1955), who allied the genus to *Gochnatia* and *Stiffia*. The same year, Ferreyra named the genus *Weberbaueriella* to accommodate an unusual specimen of Asteraceae originally identified as an *Onoseris*. Ferreyra (1955) allied his new genus *Weberbaueriella* to *Gochnatia*, *Onoseris* and *Chuquiraga*. *Chucoa* and *Weberbaueriella* were published in the same year but Ferreyra (1980) acknowledged the priority of the genus

Chucoa by placing *Weberbaueriella* in its synonymy. Both Ferreyra and Cabrera speculated that *Chucoa* is closely related to *Gochmatia*. However, morphological studies of *Gochmatia* and related genera suggested that *Chucoa*, because of its pubescent styles and acute anther appendages, is not closely related to *Gochmatia* (Freire et al., 2002). Katinas et al. (2008, Fig. 2) placed *Chucoa* in an informal group of 22 genera within their concept of tribe Mutisieae, which includes all members of Mutisieae and Onoserideae, sensu Panero and Funk (2008), but did not speculate further as to the sister taxon. Included in this group, because they share a similar style and anther morphology, were also the genera *Catamixis*, *Oldenburgia*, *Hyaloseris* and *Dinoseris*. However, these four genera have been shown to belong to other lineages of Asteraceae (Panero and Funk, 2008; Panero, 2008).

Given these multiple hypotheses of relationship based on morphological studies, we decided to include *Chucoa ilicifolia* in a phylogenetic analysis of Mutisioideae using chloroplast DNA so as to provide molecular evidence bearing upon the phylogenetic relationship of *Chucoa*.

MATERIALS AND METHODS

DNA was extracted from 0.25g dried leaf material of *Chucoa*, *Onoseris onoseroides* and *Urmenetea* using Qiagen's DNeasy Plant Mini Kit following the manufacturer's protocol for dried leaf material. Efficacy of the DNA extract was tested empirically using standard polymerase chain reaction (PCR) protocols and primers detailed in Panero and Crozier (2003) and Panero and Funk (2008) for the following chloroplast loci: *matK*, *ndhD*, *ndhF*, *rbcL* and *rpoB*. PCR reactions were screened using agarose gel electrophoresis. Reactions with visible results were cleaned using QIAquick PCR purification columns and 4 microliters of each used as template DNA in cycle sequencing reactions following the protocols of the ABI Big Dye Terminator 3.1 Cycle Sequencing Kit. Cleaning of the sequencing reactions using the Millipore MultiScreen 96-Well Filtration Plate and sequencing was performed by the University of Texas ICMB Core DNA Facility on an ABI 3730 DNA analyzer. Raw sequence data were proofread using Sequencher 4.8 (Gene Codes Corporation). *Chucoa*, *Onoseris onoseroides* and *Urmenetea* sequences were aligned

by eye with a subset of 19 taxa of Mutisioideae of the 108-taxon *matK*, *ndhD*, *ndhF*, *rbcL* and *rpoB* alignments used in previous phylogenetic studies (Panero and Funk, 2008).

Phylogenetic trees were constructed for the 22-taxon *matK*, *ndhD*, *ndhF*, *rbcL* and *rpoB* data sets in combination using the maximum parsimony criterion implemented in PAUP*4b10. Branch support was assessed using a full heuristic bootstrap analysis with 1000 replications. The genus *Acicarpha* (Calyceraceae) served as outgroup.

RESULTS AND DISCUSSION

Parsimony analysis of the multi-locus data matrix produced a single tree (Fig. 1) that placed *Chucoa ilicifolia* neither close to *Chuquiraga* nor *Stiffia* nor *Gochnatia*. Instead, *Chucoa* was found sister to *Onoseris onoseroides* (Mutisioideae-Onoserideae) with strong (100%) bootstrap support, highlighting Ferreyra's observation.

The *Onoseris* clade, including the type species of *Chucoa* and *Onoseris*, is also statistically supported (100% bootstrap), warranting the inclusion of *Chucoa* in the genus *Onoseris*. To formalize this transfer, the following combination is proposed:

Onoseris ilicifolia (Cabrera) Panero, **comb. nov.** Basionym *Chucoa ilicifolia* Cabrera, Bol. Soc. Argent. Bot. 6: 40. 1955. Type: Peru: La Libertad, Prov. Santiago de Chuco, Angasmarca-Tulpo, A. López Miranda 1090 (holotype: LP).

A second species of *Chucoa*, *C. lanceolata*, has been recently proposed (Sancho et al., 2005). The placement of this taxon awaits molecular studies.

ACKNOWLEDGMENTS

I thank M. Dillon of the Field Museum for material of *Chucoa ilicifolia* and Tom Wendt, TEX-LL herbarium curator, for locating specimens of *Chucoa*. I thank Bonnie S. Crozier and B. L. Turner for reviewing the manuscript and B. León and A. Cano for copies of R. Ferreyra's publications and photos of the holotype of *C. lanceolata*.

Sequencing of the *matK*, *ndhD*, *ndhF*, *rbcL* and *rpoB* genes was funded by grant NSF DEB 0344116.

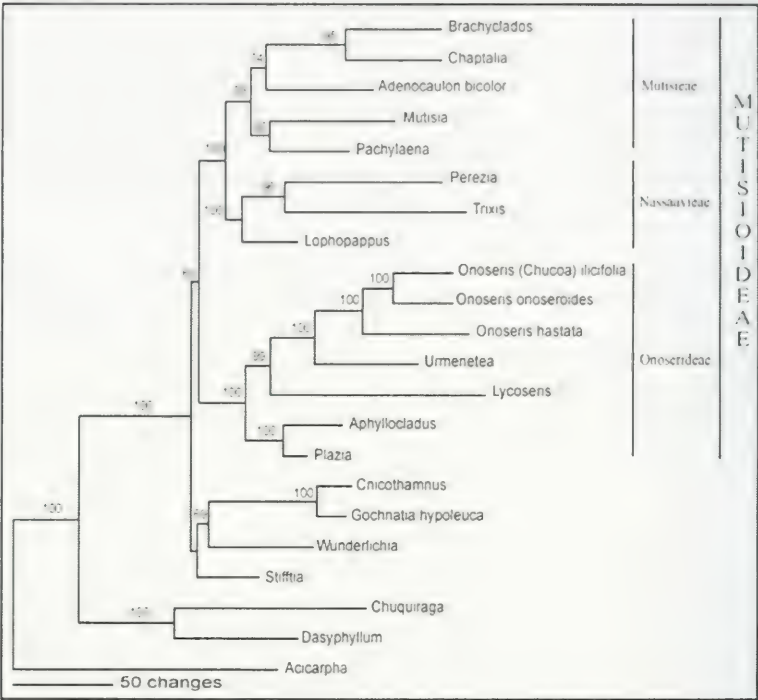


Fig.1. Single most parsimonious tree based on the MP analysis of five concatenated chloroplast genes. 422 of the 13,209 nucleotide sites were parsimony informative. Numbers above branches indicate percent bootstrap support values.

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Appendix 1. Voucher information and GenBank Accession numbers for sequences of *Onoseris ilicifolia*, *Onoseris onoseroides*, and *Urmenetea*. Voucher information listed in the following order: taxon name, collection, country of origin, herbarium. Genbank numbers listed in the following order: *matK*, *ndhD*, *ndhF*, *rbcL*, *rpoB*. *Onoseris ilicifolia* (Cabrera) Panero, Sagástegui et al. 16626, Peru, F. GQ890332, GQ890335, GQ890338, GQ890341, GQ890344. *Onoseris onoseroides* (H.B.K.) B. L. Rob., McVaugh 22341, Mexico, TEX. GQ890333, GQ890336, GQ890339, GQ890342, GQ890345. *Urmenetea atacamensis* Phil., Panero & Crozier 8446, Chile, TEX. GQ890334, GQ890337, GQ890340, GQ890343, GQ890346.

**PLECOSTACHYS SERPYLLIFOLIA (ASTERACEAE)
NATURALIZED IN CALIFORNIA**

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ABSTRACT

Plecostachys serpyllifolia, a small, sprawling shrub endemic to South Africa, is reported as naturalized for the first time for California. *Plecostachys serpyllifolia* is widely cultivated and likely escaped from residential gardens, commercial landscape plantings, or other sources. In southern California, it behaves as a facultative halophyte and a facultative wetland species that has naturalized in alkaline wetlands and moist sandy to rocky alkaline to saline sites mostly along the immediate coast (see photo on rear cover). Accordingly, we propose that *P. serpyllifolia* be added to the National List of Plants that Occur in Wetlands. We provide voucher documentation, and also review its distribution, ecology, and mode of introduction. *Phytologia* 91(3): 542-565 (December, 2009).

KEY WORDS: *Plecostachys serpyllifolia*, California, halophyte, hydrophyte, naturalized, wetlands

Plecostachys serpyllifolia (P.J. Bergius) Hilliard & B.L. Burt has not been reported previously in treatments of the Asteraceae that address nonnative species growing outside of cultivation in California (Hickman 1993; Bossard et al. 2000; Hrusa et al. 2002; DiTomaso & Healy 2003; Roberts et al. 2004; Rebman & Simpson 2006; Bossard & Randall 2007; Clarke et al. 2007; DiTomaso & Healy 2007; Riefner &

Boyd 2007; Grewell et al. 2007; Dean et al. 2008; Roberts 2008; Jepson Flora Project 2009). *Plecostachys serpyllifolia* was not included in the recent Flora of North America treatment of Gnaphalieae (Nesom 2006), nor has it been reported at all for North America (USDA, NRCS 2009).

Voucher specimens: **U.S.A.: CALIFORNIA: Los Angeles Co.**, City of Malibu, Zuma Lagoon at Westward Beach Rd., UTM (NAD 83) 11S 0331907E 3765293N, elev. 3 m, rare, moist sand around lagoon, 6 Aug 2004, *Riefner 04-367* (TEX), same locality, 10 Nov 2007, *Riefner 07-494* (RSA); City of Malibu, ocean bluff W of El Matador State Beach, UTM (NAD 83) 11S 0326052E 3768035N, elev. 2-6 m, local, seep on sea cliff with evaporate salt crust, 27 Dec 2008, *Riefner 08-385* (RSA, TEX); City of Malibu, ocean bluff W of El Matador State Beach, UTM (NAD 83) 11S 0326009E 3768041N, elev. 2-6 m, locally common on sea cliff ledges and seep with evaporate salt crust, 27 Dec 2008, *Riefner 08-387* (RSA, TEX); City of Malibu, ca. 0.2 mi E of La Piedra State Beach, UTM (NAD 83) 0325912E 3768075N, elev. ca. 3-6 m, common and invasive on coastal strand and bluff slope wetlands, 9 Jun 2009, *Riefner 09-108* (CDA, RSA, SBBG, SD, TEX, UC, UCR); City of Malibu, ca. 0.25 mi W of La Piedra State Beach near El Pescador State Beach, UTM (NAD 83) 0325662E 3768092N, elev. ca. 3-9 m, common and invasive on sea cliffs, mesic coastal bluff scrub, and slope wetlands, 9 Jun 2009, *Riefner 09-113* (CDA, RSA, SBBG, SD, TEX, UCR); City of Malibu, vicinity of La Piedra State Beach, UTM (NAD 83) 0325663E 3768090N, elev. ca. 4-6 m, common, mesic coastal bluff scrub, 9 Jun 2009, *Riefner 09-118* (RSA, TEX). **Orange Co.**, City of Lake Forest, Aliso Creek, S side of Portola Pkwy. and W of El Toro Rd., UTM (NAD 83) 11S 0439205E 3724613N, elev. 225 m, uncommon, seepage area on sandy alluvial terrace with evaporate salt crust, 9 Sep 2005, *Riefner 05-654* (RSA), same location, 16 May 2009, *Riefner 09-57* (RSA); City of Irvine, N side of Irvine Blvd. at SR-133 on-ramp, UTM (NAD 83) 0431786E 3728837N, elev. 64 m, rare, growing in sandy roadside wash, 26 Jul 2006, *Riefner 06-319* (RSA), not persistent in 2009; City of Newport Beach, Dover Beach, Newport Bay, vicinity of Morning Star Ln. and Polaris Dr., UTM (NAD 83) 0416290E 3720550N, elev. 3 m, rare, growing in coastal bluff scrub above high tide zone, 18 Mar 2007, *Riefner 07-153* (CDA, RSA); City of Laguna Beach, ocean bluff vicinity of West St. and Pacific Coast Hwy., UTM (NAD 83) 11S 0430540E 3707490N, elev. 4 m, local, coastal strand and bluff seep, 22 Oct 2008, *Riefner 08-308* (RSA, TEX); City of

Laguna Beach, vicinity of West St. and Pacific Coast Hwy., UTM (NAD 83) 11S 0430418E 3707700N, elev. 5 m, locally common, coastal bluff ledges, seep, and coastal strand, 30 Dec 2004, *Riefner 04-681* (RSA), same locality, 22 Oct 2008, *Riefner 08-312* (RSA, TEX); City of Dana Point, beach near Salt Creek, vicinity of Ritz Carlton Resort, UTM (NAD 83) 11S 0432734E 3704750N, elev. 2.5 m, uncommon, coastal strand-lagoon edge, 18 Jul 2009, *Riefner 09-151* (CDA, RSA, UC, UCR). **Riverside Co.**, City of Temecula, Vine St. at Peach Tree St., UTM (NAD 83) 11S 0491837E 3701394N, elev. ca. 341 m, rare, roadside ditch in sandy soil, 22 Aug 2006, *Riefner 06-395* (CDA, RSA, TEX), not persistent in 2009; City of Temecula, Wolf Valley Rd. at Wolf Creek Rd., UTM (NAD 83) 11S 0490185E 3702408N, elev. ca. 341 m, local, roadside ditch at edge of field, 22 Aug 2006, *Riefner 06-397* (CDA, RSA), not persistent in 2009; City of Temecula, Pechanga Pkwy. at Pechanga Resort Dr., UTM (NAD 83) 11S 0490557E 3701614N, elev. 338 m, weed in parking lot garden, 16 Dec 2008, *Riefner 08-369* (RSA, TEX). **San Diego Co.**, Leucadia, vicinity of Moonlight Beach, ca. 0.25 mi N of B St., UTM (NAD 83) 11S 0471954E 3657223N, elev. 2 m, uncommon, moist sand in perennial bluff seep with evaporate salt crust, 20 Apr 2009, *Riefner 09-31* (RSA, TEX). **Santa Barbara Co.**, City of Carpinteria, vicinity of Padaro Ln. at 101 Fwy., UTM (NAD 83) 11S 0265278E 3810619N, elev. ca. 4 m, uncommon weed in hedgerow, 30 Jan 2009, *Riefner 09-11* (CDA, RSA, TEX, UCR). **Ventura Co.**, City of Oxnard, Mandalay Bay, vicinity of Chesapeake Dr. and Viewpoint Pl., UTM (NAD 83) 11S 0294330E 3785124N, elev. 2 m, local, open sandy scrub along inlet channel and adjacent irrigated landscapes, 9 May 2009, *Riefner 09-50* (RSA, TEX).

Plecostachys serpyllifolia has in the past been placed in *Helichrysum*, but it now resides in a separate genus created for it and its close relative *P. polifolia* (Thunb.) Hilliard & B.L. Burt. Molecular studies (Bayer et al. 2000) have confirmed the distinctiveness of *Plecostachys* and have shown it to be most closely related to the monotypic genus *Tenrhynea* of South Africa.

Both species of *Plecostachys* are native to the coastal regions of southern Africa. *Plecostachys serpyllifolia* is restricted to South Africa and grows on sandy coastal flats or damp slopes mostly near the sea. It has also been documented from an alkaline fen, where it is apparently rare

(Martin 1960). *Plecostachys polifolia* occurs mostly in South Africa but also barely reaches into Swaziland – it grows mostly in mountainous regions and usually in damp places along streams or cliffs near forests (Hilliard 1983; Goldblatt & Manning 2000).

Plecostachys serpyllifolia is a small to medium, straggling or mounded, much-branched shrub with white-tomentose stems and leaves, white to often pink-tinged phyllaries, and is known by the common names of Clipped Lime or Vaaltee [Afrikaans] (Bond & Goldblatt 1984). It differs from *P. polifolia* in having suborbicular or broadly elliptic leaves, 3–8 staminate florets, and involucre bracts with pure white petaloid tips that exceed the flowers (Hilliard 1983). *Helichrysum serpyllifolium* (P.J. Bergius) Less. and *H. orbiculare* (Thunb.) Druce both are synonyms of *P. serpyllifolia* (Hilliard 1983; Bond & Goldblatt 1984).

Widely cultivated in California, *P. serpyllifolia* was first introduced in the late 1980s as “*Helichrysum petiolatum microphyllum*” or “Nana” (San Marcos Growers 2009). However, it is best known in the horticultural industry as “*Helichrysum petiolare petite*” or “Petite Licorice.” Other common names include Straw Flower or Trailing Licorice. Owing to the content of volatile oils, the leaves of *P. serpyllifolia* are lightly aromatic (Tucker & Maciarello 1996), hence the references to “licorice” for its common names. Because it is drought-tolerant, easy to establish, and tolerates poor quality or recycled water used for irrigation, *P. serpyllifolia* is frequently planted in southern California (Costello & Jones 1994; UCI 2000; Los Angeles Unified School District 2007; ASLA 2008; California Friendly Plants 2008; County of Riverside 2008; Santa Barbara County 2008). *Plecostachys serpyllifolia* is also cultivated in South Africa where it is recommended for landscaping of coastal areas, alkaline sites, and wetlands (New Plant Nursery 2007; New Hope Nursery 2009).

Confusion with Other Species

Plecostachys serpyllifolia resembles *Helichrysum petiolare* Hilliard & B.L. Burt, which is also naturalized in California. The leaves of *H. petiolare* are similarly aromatic, but much larger (10–20 mm long), the heads are larger, and the achenes are smooth-surfaced (vs. glandular-papillate in *Plecostachys*).

Plecostachys serpyllifolia is well-established in southern California, but has apparently not been detected by botanists because it occupies a relatively narrow range of specialized habitats. It may have also been overlooked because it superficially resembles *Eriogonum cinereum* Benth. (Coastal or Ashy Leaf Buckwheat), which co-occurs with *P. serpyllifolia* in the northern part of its range. *Eriogonum cinereum* is a rounded 1.5 m tall shrub found on beaches and coastal bluffs that has grayish-tomentose oval leaves and white to pink perianth lobes. The horticultural industry, however, has recognized the ability of *P. serpyllifolia* to escape gardens and naturalize in native wetland habitats (sloughs and salt marshes), and recommend that it not be planted in landscapes that interface wildland areas (San Marcos Growers 2009). *Plecostachys serpyllifolia* has also naturalized in Portugal (Almeida & Freitas 2006; GCW 2009), likely in coastal environments. Owing to its widespread use in the horticultural industry, natural adaptation to coastal habitats, and its establishment outside of cultivation in another Mediterranean climate region, it is therefore not surprising to find *P. serpyllifolia* naturalized in coastal southern California.

Occurrence as a Hydrophyte

In southern California, *P. serpyllifolia* occurs from San Diego County to Santa Barbara County. It is an occasional weed of irrigated gardens and roadside habitats where it is rarely persistent. This species has naturalized in native habitats, including moist sandy flats and open scrub around bays and lagoons, in alkaline seeps and wetlands, on rocky sea cliffs, coastal bluff scrub, the coastal strand, and alkaline streamside terraces. With the exception of rocky cliff and coastal bluff scrub habitats, most of these sites support hydrophytic vegetation, hydric soils, and hydrological conditions characteristic of wetlands. *Plecostachys serpyllifolia* is also reported to occur in salt marshes (San Marcos Growers 2009), but we have not located any populations naturalized in this habitat. Away from the immediate coast, plants migrating from gardens may not persist in dry upland habitats through the summer drought, but may naturalize if dispersed to summer-moist urban environments or native perennial wetland habitats.

Much like its behavior in South Africa, *P. serpyllifolia* is most abundant in mesic sandy to rocky seashore habitats and alkaline wetlands in coastal southern California. Many nonnative species

recently established in southern California have been identified as facultative or facultative wetland plants based on frequency of occurrence in wetlands (Reed 1988) and the “individualistic concept of a hydrophyte” (Riefner and Boyd 1997). The individualistic concept recognizes that a plant species may exhibit considerable plasticity or ecological amplitude in its adaptations to wet environments, which may represent the entire population of the species or only a subset of individuals (Tiner 1991). Identification of hydrophytes is important since the determination of the presence or absence of hydrophytic vegetation is needed to delineate the jurisdictional (legal) boundaries of wetlands, which requires the use of wetland indicator plant status ratings, species abundances, and several mathematical formulas (Reed 1988; Tiner 2006; USACE 2006). Therefore, it is critical that a species be accurately assigned a wetland indicator status; especially when an unlisted hydrophyte like *P. serpyllifolia* might be confused with upland species such as *E. cinereum* and *H. petiolare*.

The known distribution of *P. serpyllifolia* in coastal southern California is shown on Figure 1. Thirteen sites of the 18 known populations were chosen for field study, which represent the diversity of habitats, substrates, moisture conditions, and vegetation communities occupied by persistent, reproducing populations of *P. serpyllifolia* in southern California. The five California sites reported as garden weeds or from roadside habitats (Fig. 1), where the plant is rarely persistent, were not included in the field evaluations. A formal jurisdictional wetland delineation was not conducted as part of this study. Field evaluations at each of the 13 *P. serpyllifolia* data sites, however, incorporated summary findings of the presence or absence of the three attributes of hydrophytic vegetation, hydric soils, and hydrology implicit to characterizing wetland communities; see USACE Wetland Delineation Manual and Arid West Regional Supplement (USACE 1987, 2006) and USDA, NRCS (2006) for technical guidance and procedures.



FIG. 1. Known distribution of *Plecostachys serpyllifolia* in southern California; a solid circle (●) identifies the locations of naturalized populations, and an open square (□) identifies locations of garden weeds or plants collected from roadside habitats.

Qualitative field examinations of hydrology, soils, frequency of occurrence, and associations with known facultative wetland species were conducted between June and August, 2009, to 1) determine if *P. serpyllifolia* functions as a hydrophyte in southern California, and 2) provide documentation to specify a wetland indicator status for addition to the National List of Plants that Occur in Wetlands (National List).

Several editions of the National List are available for use, including an approved list (Reed 1988) and a revised list compiled by USFWS (1998). Each species on these lists is assigned an indicator status reflecting its frequency of occurrence (not degree of wetness) in wetlands, which includes: obligate [OBL, >99% found in wetlands]; facultative wetland [FACW, 67-99% found in wetlands]; facultative [FAC, 34-66% found in wetlands]; facultative upland [FACU, 1-33% found in wetlands]; and upland [UPL, <1% found in wetlands].

Field examinations determined that naturalized populations of *P. serpyllifolia* (i.e., populations reproducing spontaneously outside of cultivation in wildland habitats) grow in close association with a predominance (greater than 50 percent) of plant species typical of wetlands. Plant species that comprise the hydrophytic vegetation community closely associated with *P. serpyllifolia* are listed in Table 1. Compiling lists of species with assigned ratings can serve an important role in evaluating the wetland indicator status of plants that occupy uplands or wetlands and species that grow in highly specialized habitats, such as saline environments (Lichvar and Dixon 2007).

Table 1. Hydrophytic plants found growing with or in close proximity to naturalized populations of *Plecostachys serpyllifolia* in coastal southern California. The facultative wetland indicator status of each plant is based on the Reed (1988) and USFWS (1998) lists. An asterisk (*) indicates a tentative assignment that requires further review, a plus (+) or minus (–) designation indicates the higher or lower part of the frequency range for a particular indicator (respectively), and a long dash (—) indicates the plant is not included on the list.

ASSOCIATED PLANT SPECIES	REED (1988) INDICATOR STATUS	USFWS (1998) INDICATOR STATUS
<i>Acacia cyclops</i>	—	—
<i>Acacia longifolia</i>	—	—
<i>Agrostis stolonifera</i>	FACW	FACW
<i>Agrostis viridis</i> (syn., <i>A. semiverticillata</i> , <i>Polypogon viridis</i>)	OBL	OBL
<i>Amblyopappus pusillus</i>	FACW–	FACW–
<i>Anagallis arvensis</i>	FAC	FAC
<i>Apium graveolens</i>	FACW*	FACW*
<i>Artemisia californica</i>	—	—
<i>Arundo donax</i>	FACW	FAC+
<i>Aster subulatus</i> var. <i>ligulatus</i>	FACW	FACW
<i>Atriplex californica</i>	FAC	FAC
<i>Atriplex glauca</i>	—	—
<i>Atriplex lentiformis</i>	FAC	FAC
<i>Atriplex prostrata</i>	—	FACW*
<i>Baccharis salicifolia</i>	FACW	FACW
<i>Bassia hyssopifolia</i>	FAC	FAC
<i>Cakile maritima</i>	FACW	FACW
<i>Carpobrotus chilensis</i> (<i>C. aequilaterus</i> of early floras)	—	FAC*
<i>Carpobrotus edulis</i>	—	—
<i>Chenopodium ambrosioides</i>	FAC	FAC
<i>Chenopodium glaucum</i>	FACW*	—
<i>Chenopodium rubrum</i>	—	FACU
<i>Cortaderia selleana</i>	—	—

ASSOCIATED PLANT SPECIES	REED (1988) INDICATOR STATUS	USFWS (1998) INDICATOR STATUS
<i>Cotyledon orbiculata</i>	—	—
<i>Cotula coronopifolia</i>	FACW+	FACW+
<i>Distichlis spicata</i>	FACW	FACW
<i>Eriogonum parvifolium</i>	—	—
<i>Heliotropium curassavicum</i>	OBL	OBL
<i>Isocoma menziesii</i> var. <i>vernonioides</i> (syn., <i>Haplopappus venetus</i>)	FACW*	FAC+
<i>Isolepis cernua</i> (syn., <i>Scirpus cernuus</i>)	OBL	OBL
<i>Juncus acutus</i> subsp. <i>leopoldii</i>	FACW	FACW
<i>Juncus bufonius</i>	FACW+	FACW+
<i>Limonium arborescens</i>	—	FAC*
<i>Limonium perezii</i>	—	—
<i>Limonium ramosissimum</i>	—	—
<i>Matthiola incana</i>	—	UPL
<i>Medicago polymorpha</i> (syn., <i>M. hispida</i>)	—	FACU–
<i>Melilotus alba</i>	FACU+	—
<i>Melilotus indica</i>	FAC	FAC
<i>Myoporum laetum</i>	—	FAC*
<i>Plantago major</i>	FACW–	FAC
<i>Pluchea odorata</i> (syn., <i>P. purpurascens</i>)	OBL	FACW
<i>Polypogon monspeliense</i>	FACW+	FACW+
<i>Pulicaria paludosa</i>	—	FACW*
<i>Rhus integrifolia</i>	—	—
<i>Ricinus communis</i>	FACU	FACU
<i>Rumex crispus</i>	FACW–	FACW–
<i>Rumex maritimus</i>	OBL	FACW+
<i>Salix lasiolepis</i>	FACW	FACW
<i>Stenotaphrum secundatum</i>	FAC+	FAC+
<i>Typha domingensis</i>	OBL	OBL
<i>Typha latifolia</i>	OBL	OBL
<i>Xanthium strumarium</i>	FAC+	FAC+

Several of the species listed above lack an assigned wetland indicator status, which include *Carpobrotus edulis* (L.) N.E. Br., *Cortaderia selloana* (Schultes) Asch. & Graebner, *Limnium perezii* (Stapf) Hubb., and *Limnium ramosissimum* Maire. These species, however, are well-known invasive plants of California's estuarine wetlands (Grewell et al. 2007) and should be evaluated for the next revision of the National List. Accordingly, as a result of this evaluation, *P. serpyllifolia* frequently grows in close association with a predominance of hydrophytic plant species typical of wetlands in southern California. Outside of cultivation, *P. serpyllifolia* is occasionally found growing on mesic rocky cliff and coastal bluff scrub habitats that are influenced by ocean spray and fog-drip moisture, but do not support hydrophytic vegetation. *Plecotachys serpyllifolia*, however, has not established in dry upland communities such as coastal sage scrub, chaparral, grasslands, or in oak woodlands.

Indicators of hydrophytic vegetation and hydric soils generally provide reliable evidence that the timing, duration, and frequency of wet conditions are sufficient to support wetland communities (USACE 2006). Therefore, indicators of hydric soils and wetland hydrology were also recorded during this study to establish a frequency of occurrence of *P. serpyllifolia* in wetlands in order to specify a wetland indicator status for potential addition to the National List. Indicators of wetland hydrology summarized by USACE (2006) that are present at the 13 data sites includes Indicators A1.Surface Waters, A3.Soil Saturation, B1.Water Marks (stained rocks), B11.Salt Crusts (on rocks and alluvial surfaces), B12.Biotic Crusts (including green algal mats), and evidence of recent soil saturation such as C3.Oxidized Rhizospheres, and C4.Recent Iron Reduction. Landscape positions conducive to development of wetlands associated with these sites include a streamside terrace, fringe of lagoon or bay, toe-of-slope along coastal bluffs, and occurrences within or adjacent to high tides along ocean beaches. Hydric soil indicators (USDA, NRCS 2006) documented at the data collection sites includes Indicators S4.Sandy Gleyed Matrix, S5.Sandy Redox, F2.Loamy Gleyed Matrix, and F3.Depleted Matrix.

Table 2. Wetland attributes of hydrophytic vegetation, hydric soils, and hydrology associated with naturalized populations of *Plecostachys serpyllifolia* in coastal southern California.

DATA COLLECTION SITES	HABITATS	ATTRIBUTES OF WETLANDS PRESENT
Mandalay Bay, Ventura Co.	Bay Inlet Channel	Yes: Hydrophytic vegetation No: Hydric soils Yes: Hydrology
El Pescador (R.H. Meyer) State Beach, Los Angeles Co.	Slope Wetland	Yes: Hydrophytic vegetation Yes: Hydric soils Yes: Hydrology
La Piedra (R.H. Meyer) State Beach, Los Angeles Co.	Coastal Strand	Yes: Hydrophytic vegetation Yes: Hydric soils Yes: Hydrology
La Piedra (R.H. Meyer) State Beach, Los Angeles Co.	Coastal Bluff Scrub	Yes: Hydrophytic vegetation No: Hydric soils Yes: Hydrology
La Piedra (R.H. Meyer) State Beach, Los Angeles Co.	Slope Wetland	Yes: Hydrophytic vegetation Yes: Hydric soils Yes: Hydrology
La Piedra (R.H. Meyer) State Beach, Los Angeles Co.	Splash Zone on Cobbly Seashore	Yes: Hydrophytic vegetation Yes: Hydric soils Yes: Hydrology
El Matador (R.H. Meyer) State Beach, Los Angeles Co.	Bluff Seep	Yes: Hydrophytic vegetation Yes: Hydric soils Yes: Hydrology
Zuma Lagoon, Los Angeles Co.	Lagoon	Yes: Hydrophytic vegetation Yes: Hydric soils Yes: Hydrology
Lake Forest, Aliso Creek, Orange Co.	Alluvial Stream Terrace	Yes: Hydrophytic vegetation Yes: Hydric soils Yes: Hydrology
Laguna Beach, Orange Co.	Rocky Coastal Bluff Scrub	No: Hydrophytic vegetation No: Hydric soils No: Hydrology
Laguna Beach,	Coastal	Yes: Hydrophytic vegetation

DATA COLLECTION SITES	HABITATS	ATTRIBUTES OF WETLANDS PRESENT
Orange Co.	Strand	Yes: Hydric soils Yes: Hydrology
Dana Point, Salt Creek, Orange Co.	Coastal Strand- Lagoon	Yes: Hydrophytic vegetation Yes: Hydric soils Yes: Hydrology
Leucadia, San Diego Co.	Bluff Seep	Yes: Hydrophytic vegetation Yes: Hydric soils Yes: Hydrology

Based on qualitative field observations of wetland hydrology, hydric soils, frequency of occurrence, and associations with known facultative wetland species, *P. serpyllifolia* functions as a hydrophyte at several locations in southern California. Accordingly, we believe *P. serpyllifolia* should be added to the National List and propose a FAC* wetland indicator status. Additional regional review may be needed to specifically define its frequency of occurrence in wetlands as the species undergoes further expansions of range and colonization of non-hydrophytic vegetation communities on sea cliffs and coastal bluff scrub habitats or mesic urban environments as a garden waif.

Occurrence as a Halophyte

Plecostachys serpyllifolia has not been identified previously as a halophyte on any of the databases listing salt-tolerant plants known from around the world (Aronson 1989; Menzel & Lieth 2003). However, it has always been difficult to characterize plant responses to salinity in a way that is meaningful for extrapolation from species to species, from one set of environment conditions to another, or whether the plant is a facultative or an obligate halophyte (Chapman 1975; Koyro 2003). These issues are certainly exacerbated for species introduced to new regions. Additionally, unlike the national list of wetland plants, which defines facultative (FAC), facultative wetland (FACW), and obligate wetland (OBL) plant indicator ratings, little research has been conducted to classify obligate halophytes, i.e., plants that are exclusive to saline habitats versus facultative halophytes, i.e., plants that occupy saline and non-saline environments.

In southern California, numerous species identified as halophytes by Aronson (1989) and Menzel & Lieth (2003) frequently occupy saline and non-saline riparian and freshwater wetland habitats, and are therefore best characterized as facultative halophytes. A few examples include *Agrostis stolonifera* L., *Arundo donax* L., *Chenopodium ambrosioides* L., *Cotula coronopifolia* L., *Cyperus odoratus* L., *Eleocharis palustris* (L.) Roemer & Schultes, *Isolepis cernua* (Vahl) Roemer & Schultes, *Juncus bufonius* L., *Leptochloa uncinervis* (J. Presl) A. Hitchc. & Chase, *Paspalum distichum* L., *Plantago lanceolata* L., *Plantago major* L., *Polypogon monspeliensis* (L.) Desf., *Rumex crispus* L., *Schoenoplectus* (*Scirpus*) *californicus* (C.A. Meyer) Soják, *Typha angustifolia* L., *Typha domingensis* Pers., and *T. latifolia* L. Many of these plants grow with or in close proximity to *P. serpyllifolia*. Therefore, it is important to document known halophytes that grow in close association with *P. serpyllifolia* in southern California, which are shown in Table 3.

Table 3. Halophytic plants found growing with or in close proximity to naturalized populations of *Plecostachys serpyllifolia* in coastal southern California. Halophyte status is based on the Aronson (1989) and Menzel & Lieth (2003) databases. A long dash (—) indicates the plant is not included on the respective list.

ASSOCIATED PLANT SPECIES	ARONSON (1989) HALOPHYTE	MENZEL & LIETH (2003) HALOPHYTE
<i>Acacia cyclops</i>	Yes	Yes
<i>Acacia longifolia</i>	—	—
<i>Agrostis stolonifera</i>	Yes	Yes
<i>Agrostis viridis</i> (syn., <i>A. semiverticillata</i> , <i>Polypogon viridis</i>)	—	—
<i>Amblyopappus pusillus</i>	Yes	Yes
<i>Anagallis arvensis</i>	Yes	Yes
<i>Apium graveolens</i>	—	Yes
<i>Artemisia californica</i>	—	—
<i>Arundo donax</i>	Yes	Yes
<i>Aster subulatus</i> var. <i>ligulatus</i>	—	—

ASSOCIATED PLANT SPECIES	ARONSON (1989) HALOPHYTE	MENZEL & LIETH (2003) HALOPHYTE
<i>Atriplex californica</i>	Yes	Yes
<i>Atriplex glauca</i>	Yes	Yes
<i>Atriplex lentiformis</i>	Yes	Yes
<i>Atriplex prostrata</i>	Yes	Yes
<i>Baccharis salicifolia</i>	—	—
<i>Bassia hyssopifolia</i>	Yes	Yes
<i>Cakile maritima</i>	Yes	Yes
<i>Carpobrotus chilensis</i> (C. <i>aequilaterus</i> of early floras)	Yes	Yes
<i>Carpobrotus edulis</i>	Yes	Yes
<i>Chenopodium ambrosioides</i>	Yes	Yes
<i>Chenopodium glaucum</i>	Yes	Yes
<i>Chenopodium rubrum</i>	Yes	Yes
<i>Cortaderia selloana</i>	—	—
<i>Cotula coronopifolia</i>	Yes	Yes
<i>Cotyledon orbiculata</i>	Yes	Yes
<i>Distichlis spicata</i>	Yes	Yes
<i>Eriogonum parvifolium</i>	—	—
<i>Heliotropium curassavicum</i>	Yes	Yes
<i>Isocoma menziesii</i> var. <i>vernonioides</i> (syn., <i>Haplopappus venetus</i>)	—	—
<i>Isolepis cernua</i> (syn., <i>Scirpus cernuus</i>)	Yes	Yes
<i>Juncus acutus</i> subsp. <i>leopoldii</i>	Yes	Yes
<i>Juncus bufonius</i>	Yes	Yes
<i>Limonium arborescens</i>	Yes	Yes
<i>Limonium perezii</i>	Yes	Yes
<i>Limonium ramosissimum</i>	Yes	Yes
<i>Matthiola incana</i>	—	—
<i>Medicago polymorpha</i> (syn., <i>M. hispida</i>)	—	Yes
<i>Melilotus alba</i>	—	Yes
<i>Melilotus indica</i>	—	Yes
<i>Myoporum laetum</i>	—	—

ASSOCIATED PLANT SPECIES	ARONSON (1989) HALOPHYTE	MENZEL & LIETH (2003) HALOPHYTE
<i>Plantago major</i>	Yes	Yes
<i>Pluchea odorata</i> (syn., <i>P. purpurascens</i>)	Yes	Yes
<i>Polypogon monspeliense</i>	Yes	Yes
<i>Pulicaria paludosa</i>	—	—
<i>Rhus integrifolia</i>	—	—
<i>Ricinus communis</i>	—	—
<i>Rumex crispus</i>	Yes	Yes
<i>Rumex maritimus</i>	Yes	Yes
<i>Salix lasiolepis</i>	—	—
<i>Stenotaphrum secundatum</i>	Yes	Yes
<i>Typha domingensis</i>	Yes	Yes
<i>Typha latifolia</i>	Yes	Yes
<i>Xanthium strumarium</i>	—	—

Based on observations of naturalized, persistent populations in wildland habitats, *P. serpyllifolia* apparently functions as a facultative halophyte in southern California. It is nearly always closely associated with substrates having a conspicuous evaporate salt crust, grows within the salt-spray and splash zones along the seashore, and it most often grows with or in close proximity to a predominance of well-known halophytes. Halophytes are plants capable of completing their life cycle in saline environments where the salt concentration of soil solution measures at least 5 g/l total dissolved solids or 85 mM NaCl (Aronson 1989; Koyro 2003). Electrical conductivity (EC) of a soil saturation extract (EC_e) expressed as deciSiemens/meter (dS/m), however, is the preferred index of measurement used to classify saline soils and to identify halophytes (U.S. Salinity Laboratory Staff 1954; Aronson 1989). Accordingly, soil samples were collected and analyzed for pH and salinity to further clarify the potential halophyte status of *P. serpyllifolia* in southern California.

Soil samples to determine pH and salinity were collected from the same 13 wetland attribute study sites that represent the diversity of habitats, substrates, moisture conditions, and vegetation communities

occupied by *P. serpyllifolia* in southern California. Soil samples were collected in early June or in late August, 2009, from a depth of 0–10-inches within the root-zone of *Plecostachys* plants, mixed to produce a composite sample, cataloged, and then shipped to Wallace Laboratories (El Segundo, California) for analysis. The five California *P. serpyllifolia* populations reported as garden weeds or from roadside habitats, where the plant is rarely persistent, were not sampled for analysis.

Table 4. Results of pH and salinity analysis of soil samples collected from sites that represent the diversity of habitats typically occupied by *Plecostachys serpyllifolia* in southern California; pH and ECe dS/m measured in a saturation paste extract. The higher the ECe the more salts are in the soil.

DATA COLLECTION SITES	HABITATS	pH	ECe dS/m
Mandalay Bay, Ventura Co.	Bay Inlet Channel	6.92	63.20
El Pescador (R.H. Meyer) State Beach, Los Angeles Co.	Slope Wetland	7.51	43.20
La Piedra (R.H. Meyer) State Beach, Los Angeles Co.	Coastal Strand	7.76	2.23
La Piedra (R.H. Meyer) State Beach, Los Angeles Co.	Coastal Bluff Scrub	6.97	43.60
La Piedra (R.H. Meyer) State Beach, Los Angeles Co.	Slope Wetland	7.15	4.52
La Piedra (R.H. Meyer) State Beach, Los Angeles Co.	Splash Zone on Cobbly Seashore	7.31	39.00
El Matador (R.H. Meyer) State Beach, Los Angeles Co.	Bluff Seep	7.26	11.70
Zuma Lagoon, Los Angeles Co.	Lagoon	7.08	10.30
Lake Forest, Aliso Creek, Orange Co.	Alluvial Stream Terrace	7.41	14.60
Laguna Beach, Orange Co.	Rocky Coastal Bluff Scrub	7.55	35.80
Laguna Beach, Orange Co.	Coastal Strand	7.68	6.87
Dana Point, Salt Creek,	Coastal Strand—	7.70	3.51

DATA COLLECTION SITES	HABITATS	pH	ECe dS/m
Orange Co.	Lagoon		
Leucadia, San Diego Co.	Bluff Seep	7.50	5.36

The Soil Survey Division Staff (1993) defines classes of soil salinity based on electrical conductivity as follows: non-saline (0 – 2 dS/m); very slightly saline (2 – 4 dS/m); slightly saline (4 – 8 dS/m); moderately saline (8 – 16 dS/m); and strongly saline (>16 dS/m). The minimum criterion used to determine if a plant behaves as a halophyte is an EC of at least 7 – 8 dS/m (Aronson 1989). Accordingly, based on preliminary analytical data, and its consistent occurrence with known halophytes, *P. serpyllifolia* appears to function as a facultative halophyte in southern California. Since salinity tolerance of plants is affected by many accessory factors (spring moisture, late season evapotranspiration that concentrates salts, drainage, nutrition, etc.), additional research to gain detailed knowledge regarding the salt tolerance of *P. serpyllifolia* and the mechanisms that enable this plant to grow in saline environments is warranted.

Competition with Native Species

Based on information available in the literature, *P. serpyllifolia* is not an aggressive colonizer in its native South Africa, nor does it appear to be invasive in Portugal. However, under optimal conditions of moisture, pH, and mild coastal environments in southern California, *P. serpyllifolia* can grow to nearly 1.5 m tall and form a dense colony of coalescing shrubs that can displace native species.

Plecostachys serpyllifolia has been observed to compete for space with *Juncus acutus* L. subsp. *leopoldii* (Parl.) Snog., which is a rare species of interest to the California Native Plant Society (CNPS List 4). Other rare plants, including *Eleocharis parvula* (Roemer & Schultes) Link ex Bluff, Nees & Schaurer (CNPS List 4), *Lycium californicum* Nutt. (CNPS List 4), *Malacothrix saxatilis* (Nutt.) Torrey & A. Gray var. *saxatilis* (CNPS List 4), and *Suaeda taxifolia* (Standley) Standley (CNPS List 4) were also observed growing in proximity to *P. serpyllifolia*. With the exception of *Malacothrix saxatilis*, each of these plants has been identified as a halophyte by Aronson (1989) and Menzel & Lieth (2003). Accordingly, the side-by-side comparisons of

halophytes versus the wetland indicator status of each plant shown in Tables 1 & 3 and the pH and salinity ranges shown in Table 4 may help identify rare native plant assemblages and natural communities that may be most susceptible to colonization by *P. serpyllifolia*.

CONCLUSION AND RECOMMENDATIONS

Although *P. serpyllifolia* is widespread in coastal southern California, most populations are small and non-invasive. Preliminary observations made during field investigations suggest that it can compete for space and displace native plants, especially in alkaline wetlands and in mesic to wet saline habitats along the immediate coast. Based on the occurrence of this species with acknowledged hydrophytes growing on hydric soils, *P. serpyllifolia* should be added at a minimum to the national list of wetland plants with a facultative (FAC*) indicator status. We believe that the frequency of occurrence of this species in wetlands, its associated species in California, and the distribution of the plant in its native land, the indicator status may quite possibly be facultative wetland (FACW).

Results of preliminary laboratory analysis indicate that *P. serpyllifolia* occupies very slightly saline to strongly saline soils throughout its known range in coastal southern California. Based on the occurrence of this species with acknowledged halophytes, its association with salty substrates, tolerance to recurrent wetting by high tides and salt sprays along the seashore, and the coastal distribution of the plant in its native land, *P. serpyllifolia* should be considered for addition to future revisions of the world-wide halophyte database.

Finally, there is concern about the possible invasiveness of this species. *Plecostachys serpyllifolia* apparently becomes invasive only in a narrow range of seashore habitats, which support numerous small native forbs and several rare species that might be displaced by this shrub. Given that, it is recommended that urban landscape programs discourage planting of *P. serpyllifolia* in coastal regions in order to deter its spread and establishment elsewhere in southern California.

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A NEW COMBINATION IN NORTH AMERICAN *LATHYRUS*

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Phytologia 91(3): 566-567 (December, 2009).

A proposal (#1396) by Reveal (1999) to conserve *Lathyrus polymorphus* Nutt. was not recommended by the nomenclature review committee (Brummitt 2000; McNeil et al. 2006) leaving *L. decaphyllus* Pursh to stand as the name for the native *Lathyrus* of the central Great Plains. *Lathyrus decaphyllus* ranges from northern Texas north to southwestern South Dakota, west to eastern New Mexico and Colorado and east to eastern Oklahoma, Kansas, and Nebraska. It is found in two forms: glabrous - which is most common in the eastern part of the range - and villous-pubescent, which is more often found in the west-southwest part of the range. Hitchcock (1952) made a nomenclatural distinction between these two populations. I believe this distinction is appropriate and propose the following combination for the pubescent form of the species:

Lathyrus decaphyllus* var. *incanus* (J. G. Smith & P. A. Rydberg) S. L. Broich, **comb.nov.*

Lathyrus ornatus var. *incanus* J. G. Smith & P. A. Rydberg Fl. Neb., Rosales 64. 1895. *L. incanus* (Smith & Rydberg) Rydb., Bull. Torrey Bot. Club 33:144. 1906. *Lathyrus stipulacea* var. *incanus* (Smith & Rydb.) Butters & St. John Rhodora 19:163. 1917. *Lathyrus polymorphus* ssp. *incanus* (Smith & Ryd.) C. L. Hitchcock Univ. Wash. Publ. Biol. 15:35. 1952.
TYPE: Nebraska: Sheridan County, *Smith & Pound*, 49, 1892. (NEB 177806).

ACKNOWLEDGEMENTS

I am grateful to Dr. Robert Kaul for his help in tracking down the type of *L. ornatus* var. *incanus* at NEB, Drs. Laura Morrison and Kanchi

Gandhi for reviewing the manuscript and Drs. Michael Vincent and Jay Raveill from the Flora of North America staff for their support of my work on *Lathyrus* and *Vicia* for the FNA project.

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NEW TRIBES IN ASTERACEAE

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ABSTRACT

The tribal names *Corymbieae*, *Gymnarrheneae*, *Hecastocleideae*, *Pertyeae*, and *Wunderlichieae* were not validly published for lack of Latin descriptions. We validate these names here with short Latin descriptions. *Phytologia* 91(3):568-570 (December, 2009).

KEY WORDS: *Compositae*, *Corymbieae*, *Gymnarrheneae*, *Hecastocleideae*, *Pertyeae*, *Wunderlichieae*.

The original publication of tribes *Corymbieae*, *Gymnarrheneae*, *Hecastocleideae*, *Pertyeae* and *Wunderlichieae* shared Latin diagnoses with their corresponding subfamilies *Corymbioideae*, *Gymnarrhenoideae*, *Hecastocleidoideae*, *Pertyoideae* and *Wunderlichioideae* (Panero and Funk, 2002; 2007). It has been brought to our attention that a Latin description cannot be used to validate two names. We herein include a Latin diagnosis for the tribal names.

Corymbieae Panero & V.A. Funk, **tribus nov.** Type: *Corymbium* L.
Corymbieae Panero & V.A. Funk, Proc. Biol. Soc. Wash. 115: 910.
2002, *nom. nud.*

Tribus subfamiliae *Corymbioideae*, plantae in foliis sessilibus et in laminis conduplicatis. Capitula uniflora, bracteis involucri biseriatis, dimorphis, bracteis interioribus 2, involutes; limbis corollarum salverformibus.

The tribe is monogeneric.

Gymnarrheneae Panero & V. A. Funk, **tribus nov.** Type: *Gymnarrhena* Desf. *Gymnarrheneae* Panero & V. A. Funk, Proc. Biol. Soc. Wash. 115: 912. 2002, *nom. nud.*

Tribus subfamiliae Gymnarrhenoideae, herbae perennes rosettiformes. Capitulis subterraneis et aerie; achaeniis dimorphis.

The tribe is monogeneric.

Hecastocleideae Panero & V.A. Funk, **tribus nov.** Type: *Hecastocleis* A. Gray. *Hecastocleideae* Panero & V. A. Funk, Proc. Biol. Soc. Wash. 115: 914, 2002, *nom. nud.*

Tribus subfamiliae Hecastocleidoideae, capitulescentiis biordinatis in capitulis solitariis in bracteis spiniferis.

The tribe is monogeneric.

Pertyeae Panero & V.A. Funk, **tribus nov.** Type: *Pertya* Schultz-Bip. *Pertyeae* Panero & V.A. Funk, Proc. Biol. Soc. Wash. 115: 915. 2002, *nom. nud.*

Tribus subfamiliae Pertyoideae, corollis lobis profunde dissectis variabiliter connatis distinctae

The tribe contains six genera: *Ainsliaea* DC., *Catamixis* Thoms. (see Panero, 2008), *Diaspananthus* Miq. (sometimes included in *Ainsliaea*, see Freire, 2007), *Macroclinidium* Maxim., *Myriphois* Bunge, and *Pertya* Schultz-Bip.

Wunderlichieae Panero & V.A. Funk, **tribus nov.** Type:

Wunderlichia Riedel ex Benth. & Hook. f. *Wunderlichieae* Panero & V.A. Funk, Phytologia 89: 357. 2007, *nom. nud.*

Tribus subfamiliae Wunderlichioideae (in combinatione) foliis crasse coriaceis aut deciduis, corollis grandibus tubis antherarum exsertis, corollis plerumque actinomorphis, capitulis phyllariis multiseriatis, stylis brachiis papillatis aut laevibus, et cypselis plerumque cylindricis 10-nervatis.

The tribe contains four genera: *Chimantaea* Maguire, Steyerm. & Wurdack, *Stenopadus* S.F. Blake, *Stomatochaeta* (S.F. Blake) Maguire & Wurdack, and *Wunderlichia* Riedel ex Benth. & Hook. f.

ACKNOWLEDGEMENTS

We thank James L. Reveal for bringing this nomenclatural issue to our attention. We thank B. S. Crozier, J. L. Reveal and B. L. Turner for reading the manuscript and providing helpful suggestions.

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**VARIATION AMONG THE SMOOTH-LEAF MARGINED
JUNIPERUS OF MEXICO: ANALYSIS OF nrDNA, 4CL, ABI3
AND petN-psbM SNPs**

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ABSTRACT

Analyses of sequence data from three nuclear genes and one chloroplast gene region for *Juniperus blancoi*, *J. b. var. huehuentensis*, *J. mucronata*, *J. scopulorum* and *J. virginiana* revealed that the *J. blancoi* - *huehuentensis* - *mucronata* complex is closely allied but distinct from *J. scopulorum* and very distinct from *J. virginiana*. The combined DNA data support *J. mucronata* as a sibling species to *J. blancoi* or as a variety of *J. blancoi*. Considerable differentiation was found in the *J. blancoi* population from El Oro (Carmona) and additional sampling is needed to resolve that variation. *Phytologia* 91(3): 571-580 (December, 2009).

KEY WORDS: *Juniperus blancoi*, *J. b. var. huehuentensis*, *J. b. var. mucronata*, *J. mucronata*, *J. scopulorum*, *J. virginiana*, nrDNA(ITS), 4-coumarate: CoA Ligase, Absciscic acid-insensitive 3, petN, psbM, SNPs, taxonomy.

The smooth-leaf margined junipers of Mexico consist of *Juniperus blancoi* Mart. *J. b. var. huehuentensis* R. P. Adams et al., *J. mucronata* R. P. Adams and *J. scopulorum* Sarg. (Adams, 2008). These junipers are difficult to key out and their similarities in morphology are probably indicative of their close relationship. *Juniperus mucronata* was named for its mucronate tip leaves found on plants in a single population (Adams, 2000). Farjon (2005) reduced it to *J. blancoi* var. *mucronata* (R. P. Adams) Farjon without comment. The leaf essential oils of the aforementioned taxa differ mainly quantitatively (Adams, 2000; Adams et al., 2006).

RAPD analyses (Adams et al., 2006) indicated (Fig. 1) that *J. mucronata* is closely allied with *J. blancoi* and that *J. blancoi* var.

huehuentensis is very closely allied with *J. blancoi*. The volatile leaf oils and RAPD data supported the recognition of *J. mucronata* at the species level. In addition, the heartwood of *J. mucronata* is bright purple, which is quite distinct from the other smooth-leaf margined junipers.

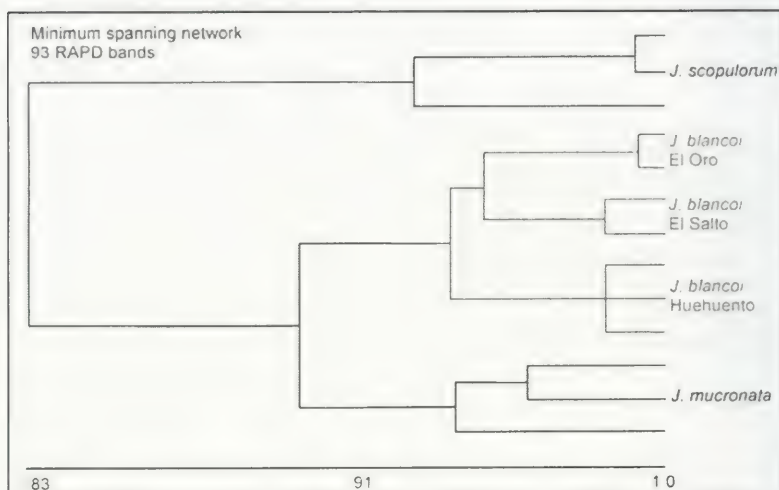


Figure 1. Minimum spanning network based on 93 RAPD bands. Adapted from Adams et al. (2006).

In an effort to better understand the affinities of these taxa, sequence data has been obtained from three nuclear gene regions: nrDNA, 4-coumarate CoA ligase (4CL) and abscisic acid-insensitive 3, (ABI3) and a cpDNA region, petN-spacer-psbM. The 4CL and ABI3 genes have been recently utilized in the Cupressaceae (Adams et al., 2009).

Peng and Wang (2008) utilized 4CL sequences to study *Thuja* species and *Thujopsis dolabrata*; they found the 4CL gene to be composed of 4 exons and 3 introns. Intron 2 was reported as 640 bp (EU183423). Aligning the GenBank sequences for *Thuja plicata* (EU183418, EU183417) and *Thujopsis dolabrata* (EU183423) enabled

us to design primers to span intron 2, and resulted in 708 - 709 bp of sequence data.

Lazarova, Zeng and Kermode (2001) reported on the occurrence of an abscisic acid-insensitive 3 (ABI3) gene homologue from *Chamaecyparis nootkatensis* (CnABI3). The ABI3 gene is composed of six exons and five introns, with the intron sizes of 105, 113, 110, ca. 1000 and 142 bp. Primers were designed in exon 4 and exon 5 to amplify intron 4 (see Materials and Methods below) and resulted in 1483-1485 bp of sequence data.

The cp region petN-spacer-psbM was used in phylogenetic studies of the Cupressaceae (Adams et al., 2009). This region resulted in 846-856 bp of sequence data.

The purpose of the present study is examine new sequence data to further clarify the nature of differentiation among the smooth-leaf margined junipers of Mexico.

MATERIALS AND METHODS

Specimens used in this study (GenBank accessions: nrDNA, petN-psbM): *J. blancoi*, Adams 6849-6851, 2 km El Oro, s of Carmona, Mexico, MX (GU120309, GU120312); *J. b. var. huehuentensis*, Adams 10247-10249, Cerro Huehuento, Durango, MX (GU120310, GU120313); *J. mucronata*, Adams 8701-8703, 10 km w of Yepachic, Chihuahua, MX on hwy 16; *J. scopulorum*, Adams 10895-10897, 11 km e of Kamas, UT, U.S.A. on UT 150 (EF608963, EF608988); *J. virginiana*, Adams 6753-6755, I35 and Hewitt exit, Hewitt, TX, U.S.A. (EF6088980, FJ46734) Voucher specimens are deposited at BAYLU.

One gram (fresh weight) of the foliage was placed in 20 g of activated silica gel and transported to the lab, thence stored at -20° C until the DNA was extracted. DNA was extracted from juniper leaves by use of a Qiagen mini-plant kit as per manufacturer's instructions.

Amplification and sequencing

ITS (nrDNA), 4CL and petN-psbM amplifications were performed in 30 μ l reactions using 6 ng of genomic DNA, 1.5 units Epi-Centre Fail-Safe Taq polymerase, 15 μ l 2x buffer E or K (final concentration: 50 mM KCl, 50 mM Tris-HCl (pH 8.3), 200 μ M each dNTP, plus Epi-Centre proprietary enhancers with 1.5 - 3.5 mM MgCl₂ according to the buffer used) 1.8 μ M each primer (see Adams, Bartel and Price, 2009 for buffer enhancers used).

Primers (5'-3'):

ITS: ITSA-42F GAT TGA ATG ATC CGG TGA AGT

ITSB+57R ATT TTC ATG CTG GGC TCT

These primers are modified from Blattner (1999).

4CL: 4CL49F AAAGAGCTCATCAAATACAA

4CL814R GAAGAGCTTCCAGCTCAG

4CL primers are from conserved sequences in exon 2 and exon 3 of *Thuja plicata* (EU183418, EU183417) and *Thujopsis dolabrata* (EU1834232) and span intron 2.

CnABI3: CnABI11F AACAAATAAGAGCAGGATGTA

CnABI357R CCAGTTTTGGTATCAGAGTA

Additional internal primers utilized:

CnABInt533R CAATATTATCACGCATTTG

CnABInt541R CACAGGAGCAATATTATCAC

CnABInt741R TTACTTGAAACAATCTATTTATGT

CnABI3 primers are from sequences in exon 4 and exon 5 of *Chamaecyparis nootkatensis* (AJ131113) and span intron 4.

petN - psbM:

petN5F: AAC GAA GCG AAA ATC AAT CA

psbM111R: AAA GAG AGG GAT TCG TAT GGA

petN and psbM primers were based on conserved sequences from *Juniperus* species.

The PCR reaction was subjected to purification by agarose gel electrophoresis (1.5% agarose, 70 v, 55 min.). In each case, the band was excised and purified using a Qiagen QIAquick gel extraction kit. The gel purified DNA band with the appropriate primer was sent to

McLab Inc. (San Francisco) for sequencing. Sequences for both strands were edited and a consensus sequence was produced using Chromas, version 2.31 (Technelysium Pty Ltd.). Alignments were made using MAFFT (<http://align.bmr.kyushu-u.ac.jp/mafft/>). Minimum spanning networks were constructed from SNPs data using PCODNA software (Adams et al., 2006).

RESULTS AND DISCUSSION

Sequencing the nrDNA (ITS region) resulted in 1139 to 1140 bp of sequence data with 14 mutational events that included 2 indels consisting of a single bp each. A minimum spanning network is shown in figure 1. *Juniperus virginiana* is the most distinct taxon with 9 SNPs separating it from *J. scopulorum* (Fig. 2). The *J. scopulorum* individuals are separated by 3 SNPs from the *J. blancoi* - *mucronata* -

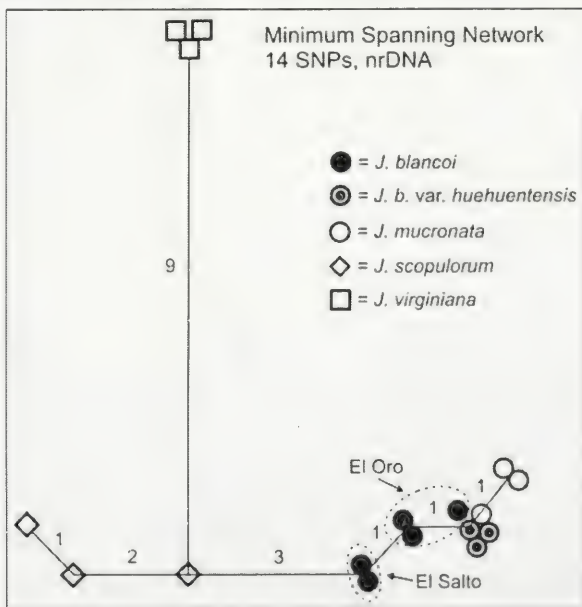


Figure 2. Minimum spanning network based on 14 SNPs from nrDNA.

huehuentensis complex (Fig. 2). Within the *J. blancoi* - *mucronata* - *huehuentensis* complex there is minor variation. Notice that there is some diversity between *J. blancoi* from El Salto and El Oro. Overall, *J. blancoi*, *J. mucronata* and *J. huehuentensis* are essentially indistinguishable in their nrDNA data.

Sequencing the petN-psbM region of cp DNA resulted in 846 to 847 bp of data with 17 SNPs found that included 7 indels. A minimum spanning network again shows (Fig. 3) *J. virginiana* to be the most distinct taxon.

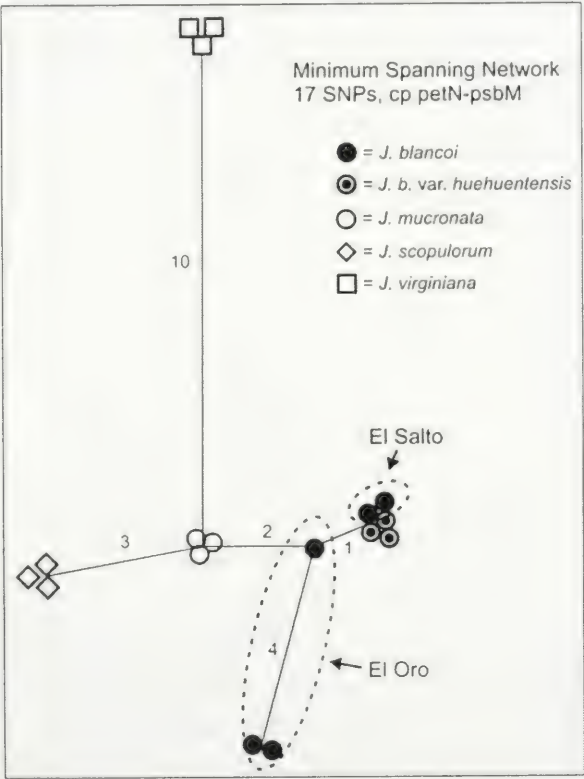


Figure 3. Minimum spanning network based on 17 SNPs from the cp petN-psbM region.

All the indels were single bases except a 7 bp deletion in *J. blancoi* individuals 6850 and 6851 from El Oro, MX (but not in 6849 from El Oro nor in the two plants from El Salto). The taxa are very uniform, except for the *J. blancoi* individuals. Two individuals of *J. blancoi* from El Oro had 4 SNPs that differentiated these plants from another *J. blancoi* plant from El Oro.

Analyses of the 4-coumarate: CoA ligase intron 2 (4CL) region resulted in 708 to 709 bp of sequence data that contained only 5 SNPs. A single indel (1 bp deletion) was found in one *J. virginiana* sample. The minimum spanning network shows little variation (Fig. 4, left) except for the separation of *J. virginiana* by 4 SNPs from other taxa.

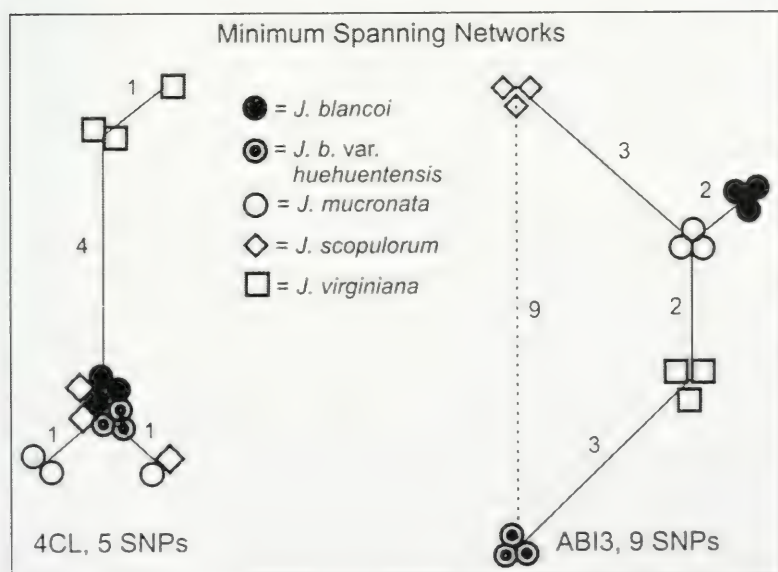


Figure 4. Minimum spanning networks using SNPs from 4CL and ABI3.

Sequencing the abscisic acid-insensitive 3 (ABI3) gene, intron 4 was difficult, but yielded 1483 - 1488 bp of data with 9 SNPs. The 9 SNPs include 4 indels and each indel occurred in all 3 plants of each

taxon. A minimum spanning network based on the 9 SNPs (including indels) reveals (Fig. 4, right) a different pattern than found in any of the other data sets. Each of the taxa are separated by 2 - 3 SNPs. ABI3 in *J. virginiana* has its greatest affinity to ABI3 from *J. mucronata* and *J. b. var. huehuentensis*.

An analysis using the SNPs from nr DNA, petN-psbM, 4CL and ABI3 sequences (4,182 bp of data) yielded 45 SNPs. The analysis gave 3 major groups: *J. virginiana*, *J. scopulorum* and the *blancoi* - *huehuentensis* - *mucronata* complex (Fig. 5). Notice that *J. blancoi* is more distinct from *J. b. var. huehuentensis* (8 SNPs) than from *J. mucronata* (5 SNPs). These data support the treatment of *J. mucronata* as a variety of *J. blancoi* or as a sibling species to *J. blancoi*.

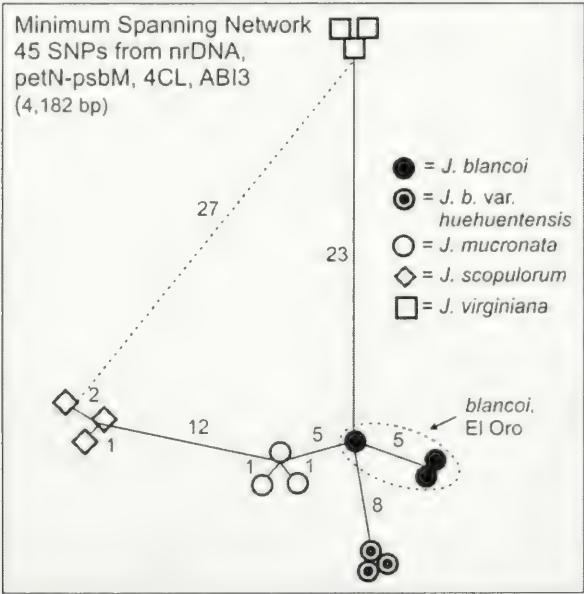


Figure 5. Minimum spanning network based on 45 SNPs from nr DNA, petN-psbM, 4CL and ABI3 sequences.

The diversity found in the El Oro samples (5 SNPs) is sufficient to warrant additional studies of *J. blancoi* populations.

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Thanks to Andrea Schwarzbach and Billie Turner for manuscript reviews. Thanks to Alicia Mastretta for making available a copy of her thesis for examination. Thanks to Tonya Yanke for lab assistance. This research was supported in part with funds from Baylor University.

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Plecostachys serpyllifolia, the light green plant in the center of the photo, naturalized in California. see Riefner and Nesom, p. 541.

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